DOCUMENT RESUME

ED 361 171 SE 053 525

AUTHOR Govindarajan, Girish, Ed.
TITLE National Association for Research in Science Teaching (NARST). Annual Meeting (65th, Cambridge, Massachusetts, March 21-25, 1992). Abstracts of Presented Papers.
INSTITUTION National Association for Research in Science Teaching.
PUB DATE Mar 92
NOTE 224p.
PUB TYPE Collected Works - Conference Proceedings (021) -- Reference Materials - Bibliographies (131)

EDRS PRICE MF01/PC09 Plus Postage.
DESCRIPTORS Biology; Chemistry; College Science; Concept Formation; Constructivism (Learning); Elementary Secondary Education; Environmental Education; Higher Education; *Knowledge Level; Problem Solving; Qualitative Research; *Science Curriculum; *Science Instruction; Science Teachers; *Scientific Concepts; Sex Differences; Student Attitudes; *Teacher Education; Technology
IDENTIFIERS Concept Maps

ABSTRACT

This product of an annual meeting presents abstracts of symposia, contributed papers, paper sets, discussion groups, reports, poster sessions, and panel presentations. Topics include: science teaching, gender differences, science education reform, constructivism, biological concepts, concept mapping, attitude/behavior change, conceptual change/understanding, assessment, problem solving/inquiry learning, science attitudes, instructional technology/communication, teacher perception/knowledge, inservice program evaluation, epistemology, cooperative learning, chemistry education, environmental education, metacognition in science, qualitative research, computer education, textbook/program evaluation, and reasoning. Author and topic indexed are attached, as well as a list of presenters with addresses. (PR)

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NARST NATIONAL ASSOCIATION FOR RESEARCH IN SCIENCE TEACHING

ED 361 171

Abstracts of Presented Papers

65th Annual NARST Meeting
Cambridge, Massachusetts
March 21-25, 1992

SE 052 225

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Abstracts of Presented Papers

65th Annual NARST Meeting
Cambridge, Massachusetts
March 21-25, 1992

Abstracts of

Symposia, contributed papers, paper sets, round table, discussion groups papers, reports, poster sessions, and panel presentations

65th Annual NARST Conference
Hyatt Regency-Cambridge
Cambridge, Massachusetts

March 21-25, 1992

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Overview

As in the past NARST proceedings of abstracts of presented papers, this volume consists of a similar format. Papers are grouped in their respective order of selection, as symposia, contributed papers, paper sets, poster sessions, panel discussions, round table discussions, reports, and discussion groups. However, a slight change has been made towards including indexes (some purists prefer the term "indices") that are more functional. To elaborate, you will find an author index, topic index, and address index with their individual complements. While every effort has been made to document all presented abstracts in their proper order, as also the indexes, it is obviously not humanly possible for any of us to do a perfect job at anything we do—we may, after all, only achieve excellence.

This volume of the NARST proceedings of abstracts of presented papers is the first major endeavor I have embarked upon as an editor. I enjoyed exercising my editorial skills in refining the abstracts (I would rather have preferred to identify them as extracts—for that is what they actually represent—but left the abstract term unaltered, because I was told that it was inextricably rooted in the annals of publications) and in aligning them in the proper order. All submitted abstracts have been published in the manner they were received. Rather than dynamically revising their text, I have exercised as little editing as necessary. Editing is different from revising in that "revising affects content and organization, whereas editing affects the surface features ..., such as transpositions, word choice, and mechanics" (Stanley, Shimkin & Lanner, 1988, p. 87).

Peripherally, many abstracts reflected a cogent and coherent style of content presentation. While some titles were exceedingly lengthy (verbose), some others were charmingly brief and to the point. Incidentally, a few individuals either neglected to or due to oversight did not type the paper title, their name(s), and institution source in the space provided. Somehow they seem to have visually bypassed even the sample abstract indicated in the Abstract Preparation instructions (*NARST NEWS*, September 1991). I have typed the passage for them—but I would expressly caution them to be more careful next time. In almost all abstracts I have not edited the titles, and have only edited very few of the titles for contextual precision of interpretation; on this note I quote, "And we edit to let the fire show through the smoke" (Plotnik, 1982, p. 31).

Academically, reading the abstracts rather closely benefitted me in four ways. First, studying who uses which words and when—this knowledge is useful because it helps an editor to process volumes of vocabulary to surface with one word/term (or sequence of words) considered apt in a particular context. The importance lies in the fact that the author's interpretation is carried by the particular word/term (conveyor, as I call it) in the text, and which the reader processes to obtain exactly that interpretation (as implied by the author) and none other.

Second, written English in the academic text periodically experiences word drop-outs at the hands of some writers lending the text dysfunctional and often misleading. For example, while reading literature on elementary school education, one sporadically comes across the sentence construction, "... Elementary Teachers ...." Teachers are not elementary; and the sentence part should have actually been worded as "... Elementary School Teachers ...." I term such word drop-outs as truncations. Such truncations often mislead the conveyed information due to unwise grammatical deletions. To quote Plotnik once more, however, "English grammar, especially as a reflection of North American usage, has as many cults and priests as there are variations in how educated people express themselves. Sometimes grammar seems not a skill, but a cabala" (Plotnik, 1982, p. 45). No wonder, then, that words like abstract instead of extract (or, perhaps, summary) have become so inextricably rooted.

Third, I found it quite enlightening to read about the research endeavors that the participants are eager to share with the audience in their respective sessions. Each abstract contains its characteristic richness in terms of the information value inherent in the conduct and results of the research. Readers are welcome to study the abstracts that appeal to their interest, and arrive at their own conclusions of interpretation. (Readers are also welcome to peruse the address index, in this document, to communicate with the authors.) My specific area of interest, in alignment with my linguistic abilities, is qualitative studies. And I enjoyed reading the abstracts on this terrain, too. When knowledgeable individuals and professionals contribute to learning, it is, indeed, a tribute to knowledge.

Fourth, like any discerning editor in the field, I am quite aware that the editor's task, though arduous, is not one that emphasizes perfection of the written art. While writing about anything, academic or non-academic, none of us is or can be perfect; we only tend to do our best toward

excellence. I have particularly benefitted from this task by learning that the editor's endeavor is to exercise a diacritical effort in making the author's text as precise as possible in its implied interpretation and import. And, "the good editor is methodical and merciless in rejecting unsatisfactory copy; discriminating in editing out weaknesses and enhancing strengths of an author's text; and compassionate in preserving the author's original ideas" (Plotnik, 1982, p. 33).

Dr. Emmett Wright continues to be an excellent mentor and source of inspiration in my life. I thank him for the many opportunities sent my way. Bob Blair, as an editorial assistant, has been invaluable in the preparation of this document. His suggestions have been insightful and timely. His contributions are particularly appreciated.

Also, I appreciate the time and effort put in by student workers Amy Moors and Jason Brown toward meticulously aligning the abstracts in their proper order. My continued appreciation goes to Mary Hammel, Director, Media Services, College of Education, Kansas State University. Mary provided the human resources assistance by having Amy and Jason work with me in the preparation of this document.

Finally, thank you all for your valuable contributions.

Girish Govindarajan
Abstracts Editor

Kansas State University
March 1992

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General Session 1
A3-1

HOW CAN STUDENTS ACQUIRE USABLE SCIENTIFIC KNOWLEDGE? UNDERSTANDING AND TEACHING THE NEEDED THOUGHT PROCESSES.

Jill H. Larkin and Frederick Reif, Carnegie-Mellon University

To cope with our rapidly changing technological world, students need increasingly to acquire scientific knowledge which is flexibly usable. Our work is based on the premise that this aim, rarely achieved, requires a better understanding of the requisite cognitive processes and more explicit teaching of these. We have used small-scale experiments to identify and investigate thought processes facilitating flexible knowledge use in quantitative sciences like physics. Thus, we have formulated and tested problem-solving strategies that include methods for generating useful problem descriptions,a nd decision processes for identifying useful actions and choosing among them. We have also investigated knowledge organizations that facilitate such problem solving, as well as procedures needed for effective interpretation of scientific concepts. Insights, derived from this past work, form the basis of our current attempts to design classroom instruction for teaching better problem-solving skills and more usable scientific knowledge. Preliminary results suggest that our teaching methods enable students to solve problems more successfully and lead also to a deeper understanding of the underlying scientific concepts. However, substantial improvements are needed to make these teaching methods reliably effective when dealing with large numbers of students in classroom situations.

Symposium: Science Anxiety
B2 - 1

B2-1-1

SCIENCE ANXIETY RESEARCH.
Mary Westerback, Long Island University, C.W.Post Campus
Charlene M. Czerniak, The University of Toledo
George Davis, Moorhead State University
Louis Primavera and James R. Campbell, St. John's University

Anxiety about science and anxiety about teaching science have been topics of interest for several decades. The State-Trait Anxiety Inventory (STAI) is a standardized 40 item Likert scale that is an accurate and reliable instrument for measuring science anxiety. The first paper will discuss instruments for measuring science anxiety and summarize past research which has found that the anxiety people feel toward science is real to them, and it is a measurable construct. However, a synthesis of this research suggests that science anxiety can be attributed, at least in part, to more general variables such as information overload, testing, and certain instructional strategies. Three current studies used the STAI to measure science anxiety. Results of these studies found that anxiety toward science can be changed in a positive direction with experience (measured by time duration) in science courses or science methods training. Anxiety toward science is significantly correlated to self efficacy; academic performance in science; student curiosity, inquisitiveness, and imagination; and academic and general self concept.

EXPERIENCED SCIENCE TEACHERS TEACHING SCIENCE OUTSIDE THEIR SCIENCE AREA OF CERTIFICATION

B2-2-1

Linda R. Sanders, Christopher Newport College

The purpose of this study was to determine the differences in the planning, teaching, and reflecting of experienced science teachers when teaching a science course in their area of science certification and when teaching another science area. The study also focused on the influence of these teachers' content knowledge, pedagogical knowledge, and pedagogical content knowledge on their teaching. Experienced science teachers were observed and interviewed while teaching classes in their area of certification and in another science area they were teaching for the first or second time. Analysis revealed similarities and differences in the two areas. In both areas there were ways these teachers acted like expert teachers in similar studies, even though the content was unfamiliar in one area. Their pedagogical knowledge and pedagogical content knowledge for general science topics provided a framework for teaching outside their area.

SCIENCE LABORATORY CLASSROOM ENVIRONMENTS AT SCHOOLS AND UNIVERSITIES: A CROSS-NATIONAL STUDY

B2-2-2

Barry J Fraser & Geoff J Giddings, Curtin University;
Cam J McRobbie, Queensland University of Technology

The first phase of this research had as one of its main purposes the development, validation and use of an instrument, the Science Laboratory Environment Inventory (SLEI), which is specifically aimed at assessing science laboratory environments at upper secondary school or university level. The SLEI assesses students' or teachers' perceptions of five dimensions of classroom environment. A distinctive feature of the design of the study was that the original 72-item version of the instrument was field-tested cross-nationally and validated in six different countries, namely, Australia, USA, Canada, England, Israel and Nigeria involving 5447 students in 269 individual laboratory classes. Various item and factor analyses guided the evolution of a refined 35-item version. In the second phase of the study, a new Personal Form of the SLEI was developed and used with a further 1480 senior high school students. This data set was used to cross-validate the Class Form, validate the Personal Form and to investigate similarities and differences between the Class Form and the Personal Form on a number of outcome-environment associations.

B2-2-3

THE EFFECT OF LABORATORY VERSUS LECTURE SCIENCE TEACHING METHODS: A META-ANALYSIS.

Jacqueline A. Hykle, University of Cincinnati

While most teachers believe laboratory-based experiences are more effective than non-laboratory methods, qualitative reviews of research have yielded less definite conclusions. This meta-analysis is designed to quantitatively integrate the cumulative research which compares the effects of science instruction supported by laboratories with traditional teaching methods that do not employ labs. Over 100 effect sizes were obtained from journal articles, ERIC documents, and dissertations, representing over 1,800 students in the middle and senior high schools. Results using the unbiased, weighted mean effect sizes show that when compared to the lecture, the laboratory method has a large effect on laboratory skills and small to medium effect sizes for content achievement, process skills, and overall achievement. The use of laboratories was also found to have a positive input on student attitudes and cognitive development.

B2-2-4

THE EFFECTS OF THE BSCS MIDDLE SCHOOL SCIENCE PROGRAM ON STUDENT UNDERSTANDING OF THE NATURE OF SCIENCE,

Yvonne J. Meichtry, UW-Stevens Point

The purpose of this study was to investigate the effects of the first-year field test BSCS middle school science program on student understanding of the creative, developmental, testable, and unified nature of science. The experimental group, which used the BSCS program, and the control group, which experienced a more traditional science program, were administered a pre- and post-test using the Modified Nature of Scientific Knowlege Scale. Analyses of the results showed that student understanding of the developmental and testable nature of science decreased significantly for students in the BSCS group. Student understanding of the creative nature of science decreased significantly for students in the control group. Analyses of covariance indicated that students in the control group possessed a better understanding of the testable nature of science than did students who used the BSCS program. Implications are related to the constructivist view of learning, the development of curricula to facilitate scientific literacy, and future research endeavors.

Paper Set: Gender Differences
B2 - 3

B2-3-1

WHERE ARE THE GENDER DIFFERENCES IN SCIENCE AND WHAT DO THEY MEAN? Dale Baker, Rosemary Leary and Rick Trammel, Arizona State University.

The purpose of this study was to examine gender differences in attitude. One thousand eighty-four students were given a classroom climate instrument to identify teacher centered and student centered classrooms at grades 2, 5, 8 and 11. A subsample of 158 students were selected from the identified classrooms and given a Sentence Completion Test. Responses were categorized and analyzed using chi square. Boys and girls were more alike than different. Both liked science, agreed on the topics and teaching techniques that they liked and disliked and believed their mother would support them in a science career. Despite liking science and planning to take more science, few students planned a science career. Gender differences were found for 5 of the 20 questions. Classroom type, student centered or teacher centered, had a significant effect on attitude. Girls in student centered classrooms held negative attitudes toward science and girls in science. Boys in teacher centered classrooms held negative attitudes toward girls in science.

B2-3-2

RELIABILITY AND VALIDITY OF TWO MEASURES OF ATTITUDE TOWARD SCIENCE

Michael Piburn, Lawrence Sidlik and Sean Mulvenon

Measures of attitude toward science have produced inconsistent results, linked to flaws in their construction. An attempt was made to identify new methods, including projective techniques in interviews and pencil and paper tests. Two attitude instruments, the Sentence Completion Test and Individual and Group Attitudes Toward Science were administered to 113 students selected from 16 classrooms in grades 2, 5, 8 and 11. Coefficient alpha for Individual and Group Attitudes Toward Science was 0.57, and for the Sentence Completion Test was 0.63. ANOVA revealed significant grade level effects on attitude, but no gender differences. There were some inter-actions between sex and classroom structure.

B2-3-3

GIRLS AND SCIENCE CAREERS: POSITIVE ATTITUDES ARE NOT ENOUGH. Nancy Moffat, Rick Trammel, Lawrence Sidlick and Dale Baker, Arizona State University.

This study is part of a larger project on attitudes, that looks at classroom practices and gender differences. One thousand eighty-four students were in the sample. A subsample of 158 students were given a Sentence Completion Test and interviewed. Data from the subsample were used to determine interest in science careers and the influence of attitude, peers, parents, and classroom structure. Only 30-40% of the students were planning on a career in science despite the fact that almost all of the students liked science. For many, science was an unexamined option. More girls than boys were ambivalent about scientific careers. Ambivalence increased with grade level. Role models were important for girls' career choices. Most students defined scientific careers as laboratory work and were unaware that their chosen careers were scientific or required a background in mathematics and science. There were significant effects between gender and the perception of classroom structure.

Contributed Papers: Science Education Reform
B2-4

Effects of State-mandated Testing on Local Science Programs: Case Study of a Suburban Elementary School **B2-4-1**

Mary Lee Martens, Hofstra University

This three-year interpretive study used interviews, observations and document analysis to examine the assumptions which guided the decisions and actions of those responsible for developing, sustaining, and evaluating the State-mandated elementary science program in one relatively small, suburban district in N.Y. State.

Findings

1) Neither individually, nor collectively were assumptions acknowledged or articulated by the subjects in this study. Consequently, the subjects further assumed that they shared a common purpose. 2) Individual purposes were not necessarily in opposition to each other, but because they were never made explicit, during the course of the study, discrepancies and even conflicts began to emerge. 3) Tests were used and results were evaluated by each of the stakeholders on the basis of initial assumptions. 4) The hierarchical power structure within the district determined consequences. In presenting this study, the researcher will delineate the far-reaching consequences of events described and propose strategies for dealing with assumptions.

B2-4-2

ASSESSING THE STATE OF SCIENCE EDUCATION: WHAT'S HAPPENING IN CLASSROOMS.

Thomas M. Dana and Sharon E. Nichols, Florida State University

The purpose of this study was to conduct an evaluation of the implementation of a state-level policy to improve science, mathematics, and computer education. The study has assisted us in developing a K-12 profile of : a) how science is taught in Florida's schools; b) trends in teaching and learning strategies; c) district and state goals to improve science education; d) access and use of instructional technology ; and d) topics of staff development workshops. In addition this study has allowed us to make comparisons to national data collected about mathematics and science teaching, and has permitted us to develop a sense of the issues of greatest relevance to the improvement of mathematics, science, and computer education as we strive to become a world leader by 1999.

B2-4-3

SCHOOL SCIENCE AS A RITE OF PASSAGE

Victoria Brookhart, University of California, Riverside

Secondary school science has been portrayed as a pipeline which converts "crude" talent into a "refined" product. Making teachers' and students' experiences in and perceptions of school science unimportant, this mechanistic view of school science limits our understanding of what actually goes on in science classrooms. Alternatively, school science might be likened to a rite of passage into the scientific community. Like the pipeline metaphor, school science as a rite of passage reflects the lengthy process from "grade school to grad school." However, in the alternative metaphor, teachers and students are recognized as active participants in the construction of school science. In this paper I set forth a new conception of school science, utilizing data collected via participant observation in introductory college chemistry classrooms.

Representing school science as a rite of passage allows us to see numerous problems: the extensive and ambiguous period of separation, the distortion of science due to exaggerations within the transition period, the hierarchial arrangement of the scientific community and exclusionary characteristics of the transition stage of the rite of passage, the contradictions within science as an enterprise, and the ambivalent attitudes of students, in particular, and society, in general, towards science.

Individuals in classrooms contribute unique meanings of science, schooling, and society as they negotiate knowledge and roles. As students experience and understand school science in multiple ways, they are differentially incorporated into the science and the scientific community. Not simply a matter of tracking or access to materials, students actively participate in their own exclusion from science, acting in ways that are sensible to them.

Contributed Papers: Constructivism
B2-5

B2-5-1

EXPERIMENTING AND PROBLEM SOLVING IN A CONSTRUCTIVIST SCIENCE LABORATORY

Wolff-Michael Roth, Appleby College, and Anita Roychoudhury, Miami University

Teaching and learning in science laboratories often have been plagued with problems and the study of science through inquiry fell short of the expectations placed in them during the 1960s and 70s. Science educators have called for constructivist learning environments in which students can pursue open-inquiry and frame their own research problems. This interpretive study was designed to document students' experimenting and problem solving in such an environment. The data sources included video-tapes, their transcripts, student laboratory reports and reflections, and the teacher's course outline and reflective notes. Forty-six students from three sections of an introductory physics course participated in the study. The students showed a remarkable ability and willingness to generate research questions, to design and develop apparatus for data collection, to deal with problems arising out of the context of inquiry during implementation, and to pursue meaningful learning during the interpretation of data and graphs to arrive at reasonable answers of their research questions. The authors conclude with recommendations for training teachers to deal with the complexities of such a learning environment and with a recommendation for adopting appropriate procedures for evaluating student achievement in a constructivist laboratory context.

B2-5-2

INTERACTIONS IN A CONSTRUCTIVIST LABORATORY

Anita Roychoudhury, Miami University and Wolff-Michael Roth, Appleby College

The purpose of this study was to examine the nature of interactions among students working in groups in a constructivist science laboratory. An interpretive method was used to analyze the data gathered in three sections of a high school physics course. From the analysis emerged three modes of interaction for arriving at consensus, a collaborative mode, an adversarial mode, or by following a majority rule. According to the degree of participation by individual students, the interactions were symmetric, asymmetric, or shifting asymmetric. The nature of the group-teacher interactions varied according to the phases of the experiments, planning, data collection, or interpreting the data. Among the other positive attributes of this collaborative environment were student involvement in the task components, independence of the groups, and a general positive feeling among the students about group work.

A PROBLEM WITH CONSTRUCTIVIST EPISTEMOLOGY

B2-5-3

Michael R. Matthews, Auckland University

This paper sketches the significance of constructivism in the contemporary theory and practice of science education. It surveys some of the epistemological commitments of constructivism and mentions the scant critiques of this which have appeared in science education literature. The paper argues that the fundamental flaw with constructivist epistemology is that it is still wedded to the Aristotelian-empiricist epistemological paradigm and that it is only within that paradigm that the well known relativist implications of constructivism follow. Using the examples of Galileo and Newton, the paper shows that the Scientific Revolution changed not only Aristotelian science but also its ideal of knowledge. The basic achievement of the new science was to separate the theoretical objects or apparatus of science from the real objects in the world. Constructivism acknowledges the constructive, creative, aspect of the former, but maintains the mistaken Aristotelian and empiricist understanding of the connection between the two realms of thought and reality.

CRITICAL REFORM OF THE SCIENCE CURRICULUM: A JOURNEY FROM OBJECTIVISM TO CONSTRUCTIVISM.

B2-5-4

Kenneth Tobin, Florida State University, Deborah Tippins, University of Georgia and Karl Hook, Florida State University

The teacher in the study, one of the authors of this paper, implemented the curriculum along traditional lines utilizing two referents, teacher as controller of students and objectivism, to make sense of his role as a science teacher. However, over a four year period the teacher began to understand constructivism and gradually changed the curriculum to reflect student learning from a constructivist perspective. Based on Grundy's interpretation of Habermas' knowledge constitutive interests the teacher decided to give greater emphasis to practical and emancipatory interests and less emphasis to technical interests.

The paper describes changes in teacher beliefs and changes that were evident in the science curriculum as the teacher gave greater control to students and implemented the curriculum in accordance with constructivism. The curricular changes described in the paper will be set in the context of changes in teacher learning and changes in the school culture. Particular attention will be directed towards the influence on the science curricula of colleague science teachers and the students from the teacher's classes.

Contributed Papers: Teaching Biological Concepts
B2-6

B2-6-1

STUDENT SCIENCE KNOWLEDGE RELATED TO OREGON'S MARINE ENVIRONMENT

Michael Brody, Oregon State University

This study assessed fourth, eighth and eleventh grade students' understanding of science concepts related to Oregon's marine environment. The sample of public school students (n = 159) in 9 Oregon schools were interviewed on a variety of concept principles considered critical to a full understanding of Oregon's marine environment. Concepts related to Oregon's marine environment included; geology, physical and chemical characteristics, ecology and natural resources. Research assertions were summarized in generalized correct concept statements indicating the extent of current student science knowledge. Common misconceptions were also noted. The study considered student understanding as an integrated set or cluster of concepts and reflects a complex and integrated conception of a natural phenomena. Human constructivism, meaningful learning theory and principles related to the relevance of student schema in the design of curriculum and instructional strategies guide this work. The results of the study have implications for teaching about the marine environment. Conclusions summarize those concepts which are missing and how educators can introduce them into existing science programs and thus help learners gain an appreciation for the complex and multidisciplinary nature of the marine environment.

B2-6-2

LANGUAGE AND CHILDREN'S CONCEPTION OF PLANTS AS LIVING THINGS

Ruth Stavy and Naomi Wax, Tel Aviv University

A study on children's conception of plants as living things revealed that Israeli 6-14 year old children found greater difficulty in classifying plants as living things than children in other counties. It was suggested that the different behavior of Israeli children might be attributed to certain characteristics of the Hebrew language. In order to by-pass the use of words connected with the terms "life", "alive", etc. Hebrew speaking children in Israel and English speaking children in Canada were asked to single the odd one out of three pictures: a dog, a tree and a rock and to explain their choice ("non-verbal" task). Then they were asked to classify different objects (animals, plants and non-living objects) into living and non-living ("verbal" task). Both groups of children were less successful in the "non-verbal" task than in the "verbal" task. Hebrew speaking children performed at a lower level than English speaking children in both the "verbal" and "non-verbal" tasks. These findings might suggest that language affects scientific concept development on both the verbal and the perceptual levels.

B2-6-3

CHILDREN'S UNDERSTANDINGS OF SCIENTIFIC MODELS: ANALYSIS OF A FIFTH GRADE LIFE SCIENCE LESSON

Sandra K. Abell, Purdue University and Marie Roth, Tippecanoe School Corporation

In this study a teaching/research collaboration between a fifth grade teacher and a university science educator was implemented to examine conceptual change teaching and learning. We videotaped 2 weeks of science instruction about biological communities and trophic relationships. We found that students' sense-making about their investigations with terraria were often different from the intended curriculum. Furthermore we found that the energy pyramid model, so clear to us, was interpreted differently by our students. Many children thought the triangular model of trophic levels represented space needs of the organisms rather than energy relationships. Our findings indicate that more work is needed to elucidate conceptual change teaching strategies that will help children see scientific conceptions as intelligible alternatives to their own ideas. Our work also explores new conceptions of collaborative classroom research in science education.

B2-6-4

ADDRESSING THE NEEDS OF LOW ACHIEVING/SPECIAL EDUCATION STUDENTS IN HIGH SCHOOL BIOLOGY CLASSES: IMPLICATIONS OF A CONCEPTUAL CHANGE MODEL OF INSTRUCTION

Marcia Fetters, Michigan State University; Brian Templin, Holt High School; and Charles W. Anderson, Michigan State University

This case study highlights the experiences of four students participating in a one semester science course designed for special education students, implementing strategies to prepare them for merger second semester into a general education class. Four goal areas guided the work in this class: teaching for conceptual understanding, improving student's ability to express themselves scientifically, improving students abilities to work co-operatively, and improving students' concepts of themselves as learners. Regular classroom observations, a series of student interviews, and samples of student work, including journal writing were used to follow the development of student thinking with regard to each goal area. Students came to the class with a wide variety of limitations, including: low reading and writing skills, low interest level, and low self-confidence in their ability to do well in a science class. Evidence of improvement in each of these areas can be verified through increased class participation, changes in quality and quantity of written work, and through student interviews. As these students moved into general education biology classes the long-term effectiveness of these instructional strategies was assessed.

Contributed Papers: Concept-Mapping
B2-7

EFFECTS OF CONCEPT MAPPING AS AN INSTRUCTIONAL TOOL: A META ANALYSIS. B2-7-1

Phillip B. Horton, Michael Gallo, et al., Florida Institute of Technology

The results of the available research reports dealing with concept mapping were combined by meta-analysis to evaluate the effects on student achievement and attitude. A coding sheet was designed to facilitate the collection of key characteristics and data from the studies. The basis of design for the coding form was extracted from Hedges, Shymansky, Woodworth (1989), and effect sizes were calculated using the methods presented by Hedges, et al. (1989) and Kulik and Kulik (1989). Of the one hundred thirty-one studies that were screened, only fifteen included data relevant to this analysis. Preliminary results indicate that students employing the concept mapping technique had both higher academic achievement and more positive attitudes than students in the comparison groups.

B2-7-2

CONCEPT-MAPPING AND CHEMISTRY ACHIEVEMENT, INTEGRATED SCIENCE PROCESS SKILLS, LOGICAL THINKING ABILITIES, AND GENDER AT TEACHERS COLLEGES IN TAIWAN

WANCHU HUANG, Taipei Municipal Teachers College

This study was designed to determine the effectiveness of the concept-mapping technique on chemistry achievement by teachers college students. Relationships among gender, integrated science process skills, logical thinking abilities, and student achievement were also studied. Four intact non-science major classes, took part in this study, taught by the researcher at two teachers colleges in Taiwan. Two weeks prior to the study, experimental groups learned the concept mapping technique. All students received regular course instruction. Fifteen minutes before the end of each class period, the students received a list of concepts covered during the class period. Only groups E1 and E2 were asked to map these concepts. Groups C1 and C2 were asked to define these concepts. Based on the data analysis using ANOVA via MRC, there was no difference in chemistry achievement between students who completed concept maps and students who completed concept definitions. However, there was a significant interaction between treatment condition and TIPS II scores; students with lower TIPS II scores led to higher achievement in the treatment. The researcher concludes that the concept mapping tech-nique is an alternative learning method that may be appropriate for those lower achieving students.

B2-7-3

THE EFFECT OF CONCEPT MAPPING ON BIOLOGY ACHIEVEMENT OF FIELD DEPENDENT STUDENTS.

David J. Martin, Kennesaw State College, and Edward C. Lucy, Georgia State University

The purpose of this study was to determine the effect of using concept mapping on biology achievement of field dependent students. The study investigated achievement gains by field dependent subjects who used concept mapping during their study of biology. Random assignment of 131 subjects to treatment or control groups was made. Treatment consisted of learning concept mapping skills, and then using these skills as a study aid in biology. Treatment groups utilized concept mapping during two consecutive units; control groups studied the second unit under treatment conditions. Field dependence/independence was assessed using the Group Embedded Figures Test. Comparisons of pretest-posttest gain scores and posttest scores suggest that field dependent subjects who used concept mapping obtained higher achievement levels than those who did not. Analyses failed to confirm statistical significance due to the small sample size (31) of field dependent subjects. The observed trends support the assertion that concept mapping may help field dependent students in biology.

B2-7-4

THE EFFECTS OF HANDS-ON SCIENCE INSTRUCTION ON STUDENTS' COGNITIVE STRUCTURES AS MEASURED BY CONCEPT MAPS

Donald T. Powers, Western Illinois University and Emmett L. Wright, Kansas State University

The purpose of this study was to investigate the effects of hands-on science instruction on students' cognitive structuring of knowledge as measured by concept maps. Five intact classes of fifth graders were taught four one-week science lessons on astronomy, ecology, magnetism and pendulums. Students drew concept maps before and after instruction to illustrate the structure of their cognitive knowledge. The concept maps were subjected to data analysis using ANOVA. The results indicated that: students preferred hands-on instructional methods; they learned more science using hands-on activities; the use of hands-on science instruction promoted a positive attitude toward the study of science; students indicated no preference for concept mapping. Since cognitive changes demand an extensive duration of time, the recommendation of this study was that similar studies be conducted over a duration beyond one week.

Paper Set: Attitude/Behavior Change
B3-1

B3-1-1

ATTITUDE/BEHAVIOR CHANGE IN SCIENCE EDUCATION: PART 1- MODELS AND METHODS.

Frank E. Crawley, University of Texas at Austin, and Thomas R. Koballa, Jr., University of Georgia

The purpose of this paper, the first in a two-paper set, is to present an overview of contemporary models and methods used to conduct attitude/behavior change research in science education. Two social-psychological models will be presented: the theory of planned behavior (TPB) (Ajzen, 1985) and persuasive communication (Petty and Caccioppo, 1981). The antecedent of the TPB model, the theory of reasoned action (TRA) (Ajzen and Fishbein, 1975), will be explained along with shortcomings that led to the introduction of the TPB. It will be shown how the TPB paradigm allows science education researchers to identify salient beliefs and plan intervention strategies that maximize the chance for attitude/behavior change. Persuasive communication and the elaboration likelihood models are described next, and it is shown how researchers can design informative messages that target salient beliefs and enhance central processing of message arguments to bring about change. Collectively the TPB and persuasive communication models provide science educators with the theoretical and empirical underpinnings needed to establish an ongoing research agenda in attitude/behavior formation and change.

B3-1-2

ATTITUDE-BEHAVIOR CHANGE IN SCIENCE EDUCATION: PART II, RESULTS OF AN ONGOING RESEARCH AGENDA.

Thomas R. Koballa, Jr., University of Georgia and Frank E. Crawley, University of Texas at Austin

The purpose of this work was to identify overarching assertions about studies conducted over a period of more than five years that were guided by the theory of reasoned action or the theory of planned behavior. The reports of twenty-one studies that were guided by either theory were located and reviewed. The studies dealt numerous science-related behaviors ranging from enrollment in high school chemistry to use of teaching methods introduced during a summer workshop. The majority employed regression analysis to identify behavioral determinants and by so doing contributed to an understanding of factors that motivate students and teachers to behave as they do. Other studies used the tenets of the theoretical models to construct interventions to impact the determinants of science-related behaviors. All contributed in some way to the refinement of the instruments used to measure the behavioral determinants. Assertions regarding (1) behavioral prediction and understanding, (2) intervention design and implementation, and (3) the development of instruments to measure model variables were generated. Central to the assertions are the concepts of belief, attitude, social and situational constraints, motivation and behavior.

Panel: NARST- NET
B3-2

B3-2-1

DEVELOPING AND USING NARST-NET: A PROPOSED TELECOMMUNICATIONS NETWORK

Derrick R. Lavoie, Montana State University
James D. Ellis, Biological Sciences Curriculum Study
Larry Flick, Washington State University
William S. LaShier, University of Kansas
Norman G. Lederman , Oregon State University
Steve J. Oliver , The University of Georgia

The purpose of this panel discussion is to develop a strategic plan to establish a NARST telecommunications network so that all members, having computer and modem, can maintain communication throughout the year at a minimal cost. Such a link should greatly enhance science-education research and teaching, as well as a number of other collaborative efforts. This proposed NARST-NET must be carefully considered to best meet the needs of its members and to facilitate a more productive future for NARST. Major issues to be discussed include: choosing the most resourceful network support system, determining potential uses of the system for NARST, educating NARST members in the value and application of the NARST-NET, and the cost and effort to establish and maintain the network. One proposed software package for the NARST-NET is CONFER which can support bulletin boards, interactive conferences, E-mail, and distance learning applications.

Symposium: Using Concept-Mapping
B3-3

USING CONCEPT MAPPING AS ANALYTICAL TOOL TO ASSESS THE STRUCTURE OF STUDENTS' SCIENTIFIC KNOWLEDGE --MULTIPLE PERSPECTIVES

Joan B. Baron, Michal Lomask, Jeffrey Greig, Connecticut State Department of Education
K. Michael Hibbard, Region 15 Public Schools, Connecticut
Audrey B. Champagne. State University of New York, Albany
Eva Baker, Center for the Study of Evaluation, UCLA
Joseph Novak, Cornell University

The goal of this symposium is to discuss the processes and effects of using concept mapping as a tool to assess students' structures of scientific knowledge. Two papers describe different aspects of a study which was part of the performance assessment of high school students' knowledge and understanding of science in Connecticut. The first describes the theoretical underpinnings and the development of the assessment , describing the roles of teachers, scientists and science educators. The second describes the theoretical framework for the analysis and scoring of students' written responses by creating concept maps, followed by several examples of experts' and students' responses. The third paper describes the use of concept mapping as a tool for classroom teachers to assess their students' learning and provide information useful for improving the instructional program. The first reactor will share the perspective of the ConSAT approach developed in 1974 at LRDC. The second reactor will share the perspective of using a computer-based approach for students to generate their concept maps. The third reactor, and symposium chair, will react from the perspective of a leading contributor to the use of concept maps with a focus on their application in assessing students' knowledge structures.

Contributed Papers: Life Sciences
B3-4

CONCEPTIONS OF NATURAL SELECTION: A SNAPSHOT OF THE SENSE-MAKING PROCESS

B3-4-1

John Settlage, Technical Education Research Centers

An interpretive analysis was conducted on high school students' conceptions of natural selection. The students who were the subjects of this study were participants in a national field test of an evolution curriculum. Written responses to two essay questions each on a pretest and posttest were evaluated to determine whether or not the students made progress toward more scientifically acceptable explanations of the evolutionary process. Comparisons of the response categories between the pretest and posttest indicated that the students had made noticeable changes in their understandings of natural selection. These changes, although not always conforming to scientifically acceptable explanations, were more accurate approximations on the posttest than on the pretest. These finding are evidence against claims that the learning of evolutionary concepts is beyond the cognitive abilities of most secondary school students.

HOW DOES BIOLOGICAL KNOWLEDGE GROW?: A STUDY OF LIFE SCIENTISTS' RESEARCH PRACTICES USING LAUDAN'S TRIADIC NETWORK MODEL.

B3-4-2

Eleanor Abrams and James H. Wandersee,
Louisiana State University

In his influential book entitled Restructuring Science Education: The Importance of Theories and Their Development (1990), Richard A. Duschl presents an equipoised triadic model of the growth of scientific knowledge which is based upon the work of philosopher Larry Laudan (1984). The purpose of this study was to test that model by interviewing 10 accomplished life science researchers employed at a Carnegie Research I University--via purposive sampling, a carefully sequenced model-based interview schedule, face-to-face questioning, and propositional analysis of the interview transcripts. Results failed to confirm either the equipoised feature of the model or the Aims feature of the model, but did confirm the Theories and the Methods features. A revised, research-based, graphic version of the model was proposed for the life sciences and three implications of the study for science teaching were derived.

B3-4-3

BIOLOGY TEACHERS' PERCEPTIONS OF SUBJECT MATTER STRUCTURE AND ITS RELATIONSHIP TO CLASSROOM PRACTICE

Julie Gess-Newsome, University of Utah; Norman G. Lederman, Oregon State University

Current reform efforts in biology teaching identify the need for a synthetic treatment of important concepts. However, little research exists which delineates the global content understandings of biology teachers (herein called subject matter structures -SMS) or assesses if these understandings translate into classroom practice. The purpose of this investigation was to determine the nature of biology teachers' SMS's and the relationship of these structures to classroom practice. Case studies of five biology teachers were constructed through interviews, classroom observations, and analysis of instructional materials. Teachers were observed 15 times during their first semester of biology teaching. The data were qualitatively analyzed to determine the exhibited SMS of the teacher as elucidated from the classroom context. This SMS was compared to SMS's provided by the teachers in post-observation interviews and to the SMS generated from the text. In general, teachers' SMS's were fragmented, indicating the absence of a coherent SMS which could be used to integrate biological concepts during classroom instruction. Subconscious translation of SMS included course scope and sequence, and the selection of textbooks. Mediating variables between teachers' SMS's and classroom practice included teachers' intentions, content knowledge, pedagogical knowledge, students, teacher autonomy, and time.

Contributed Papers: Conceptual Change
B3-5

B3-5-1

IS THE ABILITY TO USE CONCEPTUAL CHANGE PEDAGOGY A FUNCTION OF PERSONAL EXPERIENCE?

René T. Stofflett, Northern Illinois University

This study examined the question of whether conceptual change content instruction can facilitate conceptual change pedagogical learning. Elementary teacher candidates (n = 27) enrolled in 2 sections of a science methods course received either traditional or conceptual change content instruction, followed by instruction about conceptual change pedagogy. Subjects were pre- and post- interviewed about their content and pedagogical knowledge and wrote conceptual change lessons which were analyzed. 12 subgroup subjects were selected and videotaped. The videotapes were analyzed for use of conceptual change strategies. The conceptual change subjects made significantly larger gains in their content knowledge than the traditional group, gave qualitatively stronger responses on the pedagogical post-test and used conceptual change strategies more consistently in their practice. Individual differences effecting results within the groups related to whether subjects had taken more science than was required, role models present (positive and negative) and use of classroom management. These results suggested that the pedagogy used in science content courses can effect how well teacher candidates understand and are able to use conceptual change pedagogy. Recommendations for science teacher education are made.

B3-5-2

STUDENT AUTONOMY AND CONCEPTUAL CONFLICT: USING THE LABORATORY TO PROMOTE CONCEPTUAL CHANGE

Susan L. Westbrook, Norman Public Schools
and Laura N. Rogers, University of Oklahoma

The present study was designed to test the hypothesis that students who select and scientifically test their own conceptions will resolve alternate conceptions relevant to the nature of that experiment. Thus,a student's alternate conception should be more pliable to change when he has chosen to investigate the validity of that conception than when the teacher or another student has selected the concept to be examined. The study involved students enrolled in three ninth grade physical science classes. The students were asked to generate and test two hypotheses concerning flotation. Conceptual progress was assessed by concept maps made by the students at three points (pre, mid, and post) in the investigation. Only 20 of the 63 students completed the three sets of concept maps. Examination of the data indicated that students tended (a) to maintain alternate conceptions they had not investigated and (b) to dispel those they had investigated.

CLASSROOM CONCEPTUAL ECOLOGIES: CONTRASTING DISCOURSE IN CONCEPTUAL CHANGE INSTRUCTION.

N. Richard Thorley, University of Rochester

B3-5-3

A framework for analyzing classroom discourse, based on the Conceptual Change Model (CCM), has recently been developed. Categories reflecting the Conceptual Ecology guide analyses of the representational modes, plausibility, fruitfulness of conceptions. Discourse samples from three high school physics classes studying mechanics and one seventh grade life science class studying photo-synthesis were analyzed. Although all classrooms had a conceptual change orientation, they showed significant differences on several key dimensions. Among these dimensions were: the extent to which students publicly expressed and evaluated their own conceptions; the tendency to focus on conceptions versus phenomena; the use of analogies, both to represent conceptions and to support their plausibility; and the tendency to emphasize verbally expressed principles versus laboratory data in evaluating the plausibility of conceptions. These results confirmed the power of the CCM-based analytical framework to provide useful insights, for both teachers and researchers, into the content of the discourse in the classrooms. It is argued that for both psychological and curricular reasons, it would be desirable to strive for instruction which is more balanced across the dimensions represented by the categories in the analytical framework, and by implication across the features of the Conceptual Ecology.

USING INSTRUCTIONAL STRATEGIES FOR CONCEPTUAL CHANGE

Rebecca Pollard, Texas A&M University

B3-5-4

Teaching the concepts of science rather than facts reflects the changes in the demands of society on science education. To fulfill that challenge, science educators must use instruction that produces conceptual change through knowledge reconstruction. However, knowledge that has been restructured by the individual learner may not accurately reflect accepted scientific information. These inaccuracies, popularly termed misconceptions, are part of the learner's prior knowledge and have been characterized as difficult to dispel. General categories of misconceptions are depicted as those due to oscillation of real and naive science, Type NI, and those due to faulty integration of information with prior knowledge, Type I. A 2 X 5 X 9 repeated measures design used the Karplus Learning Cycle as the basis for a control and treatment model. Data was collected at five points during the learning cycle to depict student's conceptual understanding. Further, nine types of conceptual change paths were defined and tabulated in order to characterize misconceptions influenced by the treatment. Preliminary findings suggest significant differences of the treatment over the control at some measures with the majority of misconception paths involving type I misconceptions.

Contributed Papers: Science Teaching
B3-6

HISPANIC STUDENTS: DISCOURSE AND SCIENCE TEACHING **B3-6-1**

Pamela S. Carroll and Alejandro J. Gallard, Florida State University

In science classrooms, students are expected to learn to use symbols that represent a wide range of objects and processes. It is a mistake to equate Hispanic students inability to use English fluently with an inability to think and construct menaings. Consideration of classroom discourse from the perspectives of limited English proficient Hispanic students and their science teachers can lead teachers toward a fuller understanding of the role of language in the construction of scientific understanding. Interpretive methods were used to gather data and included the use of video cameras, field notes, interviews of students and teachers, and classroom observations.

This study provides science teachers with ways to think of linguistic issues that affect a science classroom in non-traditional ways. Specifically we provide teachers a point of reference and entry for consideration of the notion of language and how limited English proficient students use (or are unable to use) language to make sense of what is being taught.

TEACHING COGNITIVE STRATEGIES TO SCIENCE STUDENTS. **B3-6-2**

William G. Holliday, University of Maryland

This theoretical paper on teaching cognitive strategies comprehensively elaborates on four interactive data-based models successfully used mostly by reading researchers in their development of school strategy programs designed to help students monitor and foster comprehension and problem-solving in school contexts. This paper is the final report of a three-year effort to integrate, clarify and apply a massive amount of theoretical and empirical work on teaching cognitive strategies to research efforts in science teaching. To date, strategy research work integrating cognitive, metacognitive, motivational and social models has not appeared in science teaching research publications. Perhaps this reported strategy research can provide a bases for future research and development programs under realistic classroom conditions leading to increased school achievement in science resulting in improved problem solving strategies and conceptual changes. What do successful cognitive strategy programs look like? They typically teach all the components of empirical-based instruction (i.e., cognitive and metacognitive strategies, motivation, knowledge, and social interactions) using direct, explicit methods. This line of research suggests that to encourage students to think strategically and work together, teachers need to emphasize the link between strategy use and competent performance.

TEACHING READING THROUGH IN-DEPTH SCIENCE INSTRUCTION: EXPANSION OF A CURRICULUM INTEGRATION MODEL TO AT-RISK STUDENTS IN GRADES 4 AND 5.

B3-6-3

Nancy R. Romance, Florida Atlantic University and Michael R. Vitale, East Carolina University

This study applied a curriculum integration strategy focusing upon in-depth science instruction previously shown to be effective with average and above-average grade 4 students (Romance & Vitale, in press) to address achievement and affective deficiencies of at-risk students. The 5 month strategy replaced traditional reading instruction with a 2 hour time-block focusing on science concept instruction in conjunction with content area reading skills. Paralleling findings for average to above students, standardized test results showed that the experimental at-risk students displayed significantly greater (1.26 GE) MAT-Science growth in science than controls, with older (grade 5) students also achieving significantly greater (.51 GE) ITBS reading growth. In addition, the science-based curriculum strategy had a significant affective influence upon the learning attitudes and self-confidence of the at-risk students, referencing both in-school and out-of-school learning activities in science and reading. The curricular and policy implications of the findings for how science and reading can be taught best at upper elementary school levels are discussed in terms of an underlying rationale that the structure of science concepts provides an effective context for students mastery of applied reading skills.

CONTEXT-RELATED CHARACTERISTICS OF EXPERT SCIENCE TEACHING

B3-6-4

Dennis W. Sunal, Judith a. Burry, Kathleen Boland, University of Alabama and Mark Jeness, Western Michigan University

Analysis of science teaching involving the extensive use of qualitative data was undertaken in the first year of a three year project. The goal was to identify excellent science teaching characteristics in grades four through eight. During Year I, 46 teachers were investigated from seven different states. They were nominated and selected through an extensive search process as excellent science teachers. Data collection methods included interviews, classroom observations, measurement scales, a questionnaire, and student outcome data. The results of qualitative and quantitative data analysis coupled with findings from an ongoing literature review were used to develop a composite categorical description(s) of excellent science teachers as facilitator of the learning process. A rating protocol was imposed on the student responses to the open–ended questions about their science lesson to determine confidence in the categorical descriptions. The first year results support the belief that excellent science teachers are engaging their students in activities that promote the development of accurate scientific conceptions. Through additional development, the composite will be incorporated into an evaluation model with accompanying assessment instruments.

Contributed Papers: Assessment
B3-7

B3-7-1

RELIABILITY AND VALIDITY OF A SELF-REPORTING TOOL FOR SCREENING CANDIDATES FOR SCIENCE ENRICHMENT PROGRAMS

George E. O'Brien, Florida International Univ.

Evidence for reliability and validity of Learning, Motivation, Creativity, and Leadership subscales of a Scale for Rating Behavioral Characteristics of Superior Students as self-reporting instruments was obtained from 121 students in Grades 10 to 12 and 77 of their teachers. Determination of validity of the four subscales was based on comparisons of self-report testing and subjects' scores on the California Psychological Inventory. Analyses support the Leadership subscale to have potential as a reliable and valid self-reporting tool, in screening candidates for science enrichment programs, but data do not support such use of the other three.

B3-7-2

INTERACTIVE VIDEODISC AS A TOOL FOR ASSESSING SCIENCE TEACHERS' KNOWLEDGE OF SAFETY REGULATIONS IN SCHOOLS LABS

Michal S. Lomask, Larry Jacobson and Laurin P. Hafner, Connecticut State Department of Education.

An interactive videodisc program which simulates a typical lab activity in a secondary school science course was developed and used to assess beginning science teachers' knowledge of safety management. Science education students, science majors and currently practicing teachers served as subjects in this assessment. Subjects were asked to assume the role of the lab teacher in this simulation. They were asked to identify safety violations that were committed during the simulated activity and asked to suggest preventive or corrective measures. Reliability of the IVD as an assessment instrument was determined through its internal consistency and through the level of inter-rater agreement on the quality of candidates' responses. The validity of this new assessment was studied with a known groups and concurrent criterion model. Issues related to IVD technology, assessment and science teachers' knowledge will be discussed in this paper.

B3-7-3

ALTERNATIVE ASSESSMENT OF HIGH SCHOOL LABORATORY SKILLS

Rodney L. Doran, Joan Boorman, Fred Chan and Nick Hejaily, SUNY Buffalo

The purpose of this study was to develop and validate instruments that will assess the laboratory skills of students completing the high school science course. In each of the science areas (biology, chemistry and physics), tests were developed as six laboratory tasks. Each test used a two part format with a total time of 80 minutes. Students had to plan an investigation, collect and organize appropriate data, and formulate conclusions based on calculations and graphs. Over 1000 students from 35 Ohio schools formed the sample for this study. Data is presented by skill, by task and by school. In addition, analysis for gender and school effects is included. Comments from the science teacher at the schools tested will be summarized. These comments are critical for determining the useability of these laboratory practical tests.

B3-7-4

ASSESSMENT FOR SOCIAL CONSTRUCTIVIST TEACHING: A PHILOSOPHICAL ANALYSIS.

George E. Glasson and Rosary V. Lalik, Virginia Polytechnic Institute and State University

The purpose of this philosophical analysis is to contribute to the emerging dialogue about alternative assessment practices in the science education community. In particular, we will focus on relationships between assessment practices and social constructivist epistemology. Social constructivists view learners as culturally situated active agents who create tentative and evolutionary understandings from their actions in the world. From this perspective, assessment systems cannot be based solely on acquisition of scientific knowledge, but instead should focus on examining students' understandings while attending to larger concerns about the purposes of education within a democratic and pluralistic society.

General Session 2
B4-1

EXPLORING A MULTIMEDIA CASE OF THE TEACHING AND LEARNING OF PROBABILITY: LINKING RESEARCH ON TEACHING WITH TEACHER EDUCATION

Deborah Loewenberg Ball, Michigan State University

This session will explore new ways of structuring the relationship between research on teaching and teacher education, focusing on both content and approach. The presentation will be grounded in a multimedia case of teaching and learning probability in a third grade classroom. Participants will investigate the case together, examining a number of questions that it raises about the kind of teaching called for in the current reforms. We will focus in particular on the interplay of content and pedagogy, and on the demands entailed in creating this kind of teaching in a real classroom. Drawing on our own inquiry within this case, we will then use it as a site for exploring an alternative approach to the study of teaching and consequent ramifications for teacher education. The approach we will explore in this session suggests that we could engage teacher education students and teachers in materials and methods of research, giving the direct access to problems of practice in teaching for understanding, and helping them to develop resources for constructing this kind of teaching on a day-to-day basis with actual students.

Poster Session: Conceptual Change/Understanding
B5-2a

DEVELOPMENT AND EVALUATION OF RESEARCH-BASED MATERIALS FOR TEACHING PHOTOSYNTHESIS FOR SENIOR HIGH SCHOOL STUDENTS

B5-2a-1

Ruth Amir and Pinchas Tamir, The Hebrew University of Jerusalem

The study was conducted in three phases: A. Pre-planning evaluation in which students' misconceptions about photosynthesis, teaching practices and currently used learning materials were explored. B. Development of remedial materials based one findings in phase A (research-based materials) and C. Evaluation of these materials.
Four areas of learning difficulties were identified: Basic concepts (food, energy, organic materials and autotroph), relationship between photosynthesis and transpiration, relationship between photosynthesis and respiration and the "limiting factor" concept. Evaluation of the materials followed a pretest-posttest design. The effectiveness of the treatment was further evaluated by comparing posttest results of the experimental group with those of a comparison group.

EVALUATING STUDENTS' WRITTEN LABORATORY REPORTS FOR EVIDENCE OF CONCEPTUAL AND PROCEDURAL UNDERSTANDINGS IN SCIENCE

B5-2a-2

Carolyn Keys, University of Michigan

The purpose of this study is to develop a methodology which may be used to evaluate students' written laboratory reports for procedural and conceptual understandings of laboratory activities. Questioning guidelines were distributed to eighth grade physical science students prior to their writing laboratory reports for two activities on the topic, simple machines. The guidelines encouraged the students to write more complete lab reports. A random sample of reports was analyzed for knowledge of the procedures and concepts involved in the activities. A scoring system was developed for breaking written statements into propositions, then evaluating each proposition for level of understanding. The laboratory reports were also analyzed qualitatively for student misinformation and alternate conceptions. The results indicate that analyzing written laboratory reports may be a very effective way for teachers and researchers to gain information about students' understanding of science. Ongoing research utilizes these techniques to investigate the importance of writing as an instructional strategy.

THE CONCEPTUAL KNOWLEDGE OF BEGINNING CHEMISTRY GRADUATE STUDENTS

B5-2a-3

George M. Bodner, Purdue University, and Nava Ben-Zvi, Hebrew University of Jerusalem

A 14-item exam based on questions from the misconcept literature was given to 132 entering chemistry graduate students at Purdue University over a period of three years. Results to be described in this paper show that a significant fraction of this population shared common misconcepts about chemistry and physics held by junior- and senior-high-school students, in spite of the 400-hours of lecture and 500-hours of laboratory training in chemistry specified for an ACS-approved B.S. degree in chemistry. To probe the effect of differences in the structure of the undergraduate experience on misconcept retention, the conceptual knowledge exam was translated into Hebrew and given to entering graduate students in chemistry at Hebrew University of Jerusalem. This paper will compare and contrast results obtained at the two institutions.

TEACHING ELECTRICITY WITH CAPACITORS AND CAUSAL MODELS: PRELIMINARY RESULTS FROM DIAGNOSTIC AND TUTORING STUDY DATA EXAMINING THE CASTLE PROJECT

B5-2a-4

David E. Brown, University of Illinois

The purpose of this study is to explore the effectiveness of the CASTLE curriculum (Capacitor Aided System for Teaching and Learning Electricity). Using high capacity capacitors and transient lamp lighting, students are helped to construct more sophisticated models of circuits. Data sources include diagnostic testing of experimental and control classes at schools across the nation (n = 678 students), and 5 tutoring interviews each with three students (a total of 15 sessions). Preliminary results provide grounds for some optimism regarding the effectiveness of the materials, both from diagnostic results in which experimental classes scored higher than control classes, and from students tutored who constructed more sophisticated models as a result of the tutoring. The interview protocol data also give a unique window on the students' learning, providing insights about the students' reactions to the materials and conceptual models.

STUDENT CONCEPTIONS OF NATURAL SELECTION AND ITS ROLE IN EVOLUTION: A REPLICATION STUDY AND MORE

B5-2a-5

Sherry S. Demastes, Ronald G. Good, Marshall D. Sundberg, and Michael Dini, Louisiana State University

Having a scientific knowledge of evolution is essential to an understanding of biology. However, students approach evolution with both prior conceptions and a well established belief structure. For these reasons, evolution should have a major role in conceptual change research. This study is a replication of a study by Bishop and Anderson (1990) which described students conceptions of natural selection, designed instructional materials directed toward those conceptions, and assessed the effects of instruction using these materials on both students' conceptions and belief structures. The purpose of this study is to establish the generalizability of the previous findings as well as introduce variables which will strengthen the experimental design. These variables include (a) the use of treatment groups, (b) a larger number of participating students, (c) the use of the instructors not directly involved in the research, and (d) a larger role for qualitative data in the descriptions of students conceptions.

USING CONCEPT MAPS TO EXAMINE CHANGES IN NINTH-GRADE STUDENTS' UNDERSTANDING OF SIMPLE MACHINES.

B5-2a-6

Laura N. Rogers, University of Oklahoma
and Susan L. Westbrook, Norman Public Schools

The purpose of this study was to examine the utility of implementing concept maps in a laboratory intensive curriculum. Students in ninth-grade physical science classes constructed maps before, during, and after instruction in a three-investigation unit on simple machines. Maps were scored according to Novak & Gowin (1984) and also evaluated with criteria specific to a laboratory-oriented curriculum. Data analyses indicate that concept maps are sensitive to specific shifts in student understanding occurring throughout instruction. The results of this study suggest that interpretation of concept maps is subject to the theoretical framework of the researcher.

THE RETENTION OF MEANINGFUL UNDERSTANDING OF MEIOSIS AND GENETICS

Ann Liberatore Cavallo, University of Oklahoma

B5-2a-7

This study investigated the retention of meaningful understanding of the biological topics of meiosis, the Punnett square method and the relations between these two topics. This study also explored the predictive influence of students' general tendency to learn meaningfully or by rote (meaningful learning orientation), prior knowledge of meiosis, instructional treatment (students told relations between concepts, students asked to construct relations themselves) and all interactions of these variables on the retention of meaningful understanding of the topics. A 50-item Likert instrument taken by the students and teacher ratings of their students' approach to learning (meaningful, rote) were used in combination as a measure of students' meaningful learning orientation. The mental model technique (Cavallo, 1991; Mosenthal & Kirsch, 1991) was used to assess students' meaningful-level and rote-level understandings of the topics. Students were given a pre-test mental model on meiosis (prior knowledge variable) and were randomly assigned to the two instructional treatments. Immediately following the instructional treatments, students were given a mental model test on meiosis, the Punnett square method and on the relations between these two topics. After four weeks, the students were again given the three-part mental model test. Results of correlations and multiple stepwise regressions are reported.

B5-2a-8

PUPILS' UNDERSTANDINGS OF ATOMIC STRUCTURE AND THE INTERACTIVE USE OF ANALOGY

M.Teresa Oliveira and A.Francisco Cachapuz, New University of Lisbon and Aveiro University

Recent research indicates that interactive methods of exploring analogies may help pupils to promote conceptual change. However, analogies are often used in science teaching in a traditional way, e.g., pupils are not requested to critically analyse the nature of the features being compared. In this paper we describe how a Diagnostic Analogical Worksheet (DAW) was explored by chemistry teachers to probe knowledge of 104 Portuguese pupils (9th grade) about elementary atomic structure (planetary system as the analog domain). DAW was designed to help pupils to analyse both similarities and differences between the analog and the target domain. Qualitative analysis of pupils' answers suggests: several misconceptions (e.g. "the sun is yellow but the atom is black"); focus on attributes rather than in relationships; lack of a suitable knowledge of the analog domain; non-relevant features being selected. These results are consistent with previous research. Relevant aspects were explored in subsequent lessons (small groups/whole class discussions). Teachers reported that the method exceeded their expectations. Implications for science teaching and teacher training are discussed.

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STUDENTS' MEANINGFUL UNDERSTANDINGS OF SCIENCE CONCEPTS

B5-2a-9

Ann Liberatore Cavallo and Melanie A. Reap
University of Oklanoma

The purpose of this investigation was to reveal, describe and assess rote-level and meaningful-level understandings students attained as they progressed through the learning of new concepts. This study used an assessment technique used in previous research (Cavallo, 1991; Mosenthal & Kirsch, 1991) called, "mental modeling" to ascertain the nature (meaningful, rote) of the understandings students acquired. This research also explored factors which may be related with students' acquisition of conceptually inter-related, meaningful understandings, specifically: 1) meaningful learning orientation, 2) prior knowledge 3) logical thinking ability 4) achievement motivation, and 5) locus of control orientation. The goal of this research was to attain a better understanding of how students may formulate inter-related, meaningful understandings of science concepts.

THE VALIDATION OF MISCONCEPTIONS INVOLVING MAGNETS

B5-2a-10

Gilbert Twiest, Clarion University
Meghan Twiest, Indiana University of PA

Students of all levels have science misconceptions. Numerous studies have illustrated these misconceptions about various conceptual areas. It has been established via interview and survey that these misconceptions exist and affect students' further learning. Also, these misconceptions exist, to some extent, at all age levels and across various university majors, including science. The investigators of this study developed an instrument to examine student misconceptions in the area of magnetism. Data compiled from the survey has been used in producing the final instrument. This study is still in progress as more information about student misconceptions involving magnets is revealed. Results of a final administration will be analyzed and reported.

HANDS-ON TEACHING STRATEGIES' EFFECT ON EARTH-SUN-MOON CONCEPTIONS HELD BY PRESERVICE ELEMENTARY TEACHERS

B5-2a-11

Priscilla L. Callison, University of Missouri-Columbia and Emmett L. Wright, Kansas State University.

The purpose of this study was to examine the effect of hands-on teaching strategies on preservice elementary teachers' conceptions about earth-sun-moon relationships. The strategies were designed to range from concrete to abstract and from internal to external viewer perspective. Eighty preservice elementary teachers at a large midwestern university enrolled in an elementary science methods course during the Fall of 1990 were the subjects. The researcher used the course's four laboratory sections as the basis for intact groups and treatment administration. Pre, post, and retention measures are being analyzed for any significant difference among the strategies using an analysis of convariance. Interviews of randomly selected subjects were conducted to gather further insight into conceptual development or change.

Poster Session: Problem-solving/Inquiry Learning
B5-2b

CHARACTERISTICS OF THE SUCCESSFUL NOVICE PROBLEM SOLVER: IMPLICATIONS FOR THEORY AND INSTRUCTION B5-2b-1

Mike U. Smith, Mercer Univ. School of Medicine

The videotaped records of five successful novice college student subjects solving a group of seven genetics problems were analyzed for differences and similarities between these subjects and eight other novices and nine (successful) experts. This qualitative analysis suggests that the critical characteristics of successful novice problem solvers include their:

- approach to learning (their tendency to recognize the importance of acquiring and understanding the content and typical content-specific procedures);
- approach to problem solving as a task of reasoning ;
- metacognitive awareness of the process of problem solving;
- ability to use logical argument to develop knowledge from the problem statement;
- attention to detail and to checking their solutions and solution paths; and
- positive attitude toward problem solving and toward themselves as problem solvers.

These findings imply that genetics instruction should focus on:

- encouraging students to view genetics as requiring understanding, not merely memorization;
- understanding genetic content and procedures and developing skill in their use;
- developing conducive general problem solving skills, facility at logical argument within the content, and metacognition;
- developing of positive attitudes and self images.

ASSESSING STUDENTS' ABILITIES TO CONSTRUCT AND INTERPRET GRAPHS: DISPARITIES BETWEEN MULTIPLE CHOICE AND FREE RESPONSE INSTRUMENTS B5-2b-2

Craig A. Berg, The University of Wisconsin-Milwaukee

Does the methodology used to assess graphing abilities affect the validity of research on graphing? What can be learned about students' graphing abilities when students draw their own graphs instead of assessing via a multiple-choice instrument. 1800 subjects from an urban/suburban area took part in the study including 50% male 50% female, subjects from grades 7-12, subjects from high, medium and low ability groups, and subjects from both public and private schools. The results of this study indicated: a significant difference between the frequency and types of graphs drawn by the subjects compared to the graphs chosen by the subjects; multiple choice "distractors" influenced the subjects to choose a particular answer as much as ten times the amount that subjects actually drew a similar response; younger students and low-average ability subjects were affected differently by the multiple choice instrument when compared to the older students or high ability level students. It seems that multiple choice instruments do not give us a true picture of what students can/will actually do regarding graphing abilities.

B5-2b-3

A DESCRIPTIVE STUDY OF TEACHERS ATTAINING HIGH LEVELS OF INQUIRY AMONG STUDENTS

Karen K. Lind and Kenneth E. Duckworth, University of Louisville

The purpose of this study was to apply and extend an expectancy-based model of motivation in science. Analyses of results from previous research by the authors, funded by the National Science Foundation, suggest that all students are not experiencing the same motivation in science. Qualitative research methodology was used in this study to further develop a model of teaching and learning variables that affect motivation. Teachers attaining high levels of inquiry among students in the previous research were identified and the existing qualitative data collected were analyzed. In addition, case study research methodology was utilized to determine factors that might explain the significant gains on the inquiry indices. In particular, teaching practices among African-American students were examined.

B5-2b-4

STUDENT QUESTIONING IN A COGNITIVE APPROACH TO INSTRUCTION

Emily van Zee and Vicka Corey, University of Washington
James Minstrell, Dorothy Simpson, and Virginia Simpson
Mercer Island High School

This paper reports upon an on-going investigation of questioning processes in a cognitive approach to physics instruction. In this descriptive study, we examine three contexts for student questions: laboratory experiences, class discussions, and student conversations in small groups. Data sources include audio- and video-tapes of classroom activities, interviews with students and teachers, journal entries, and copies of class handouts and student written work. We are documenting laboratory experiences based upon specific questions generated by the students and guided by a general framework supplied by the teacher. We also are analyzing ways in which teacher comments and questions influence student thinking during class discussions. In particular, we are analyzing the nature of teacher utterances that precede student questions. In addition, we are examining questions during conversations within small groups and in collaboratory exchanges among groups of students who are comparing results.

THE ROLE OF REASONING AND CULTURE IN INQUIRY SCIENCE PERFORMANCE FOR YOUNG STUDENTS. **B5-2b-5**

Murphy, Nancy, University of Alaska Fairbanks

A study by Lawson and Gibbs is replicated to verify or refute suggestions that physical, neural, developmental considerations govern cognitive stage advancement. The methods are expanded to provide additional feedback about cultural influences on logical reasoning patterns, logical-reasoning strategies inherent in effective experimental design, and the validity of teacher perceptions of students' abilities in logical reasoning. A series of logical-reasoning tasks are presented to 140 children ages five to nine from 3 discrete student populations in Alaska which range in their exposure to western thought and expectations. Unsuccessful performance on tasks will be followed by interviews and task modification to reflect experiential familiarity. This research in progress will inform stage theory in cognitive development, provide cultural considerations for cognitive psychological research, and inform agendas for inquiry science strategies with multicultural/multi-aged student populations.

Paper Set: Science Attitudes
B5-2c

ELEMENTARY TEACHER AND STUDENT ATTITUDE TOWARD SCIENCE

(Paper set) Jane Butler Kahle, Bruce E. Perry, Leonie J. Rennie and Anita Roychoudhury.

The purpose of the cross-national studies, to be presented in this session, was to elucidate elementary school teachers' and students' perceptions of science content, to assess any change in their attitudes due to participation in one of three different intervention workshops, and to investigate the roots of those attitudes in prospective teachers. All analyses probed for gender-related differences, both in teacher attitudes and behaviors toward girls and boys and in children's confidence and interest in being scientists. Follow-up interviews conducted in the U. S. study indicated that the teachers believed that boys and girls could perform equally well in science but science itself was a more appropriate career choice for men than for women. Preservice elementary teachers' views were examined as precursors of their future attitudes. The data revealed minimal effectiveness of university science courses for the modification of student perceptions related to science laboratories.

Poster Session: Instructional Technology/Communiction
B5-3a

B5-3a-1

THE TUTORIAL SOFTWARE "THE SYNAPSE " FOR 10TH GRADE BIOLOGY STUDENTS - DESCRIPTION AND EVALUATION

Jehuda Huppert ,Oranim-Haifa University
Reuven Lazarowitz, Technion Haifa

A software called "The Synapse " was developed and implemented in 10th grade biology curriculum.The biology contents include the structure of a neuron, a synapse junction and the effects of different poisons which can inhibit the action of the impuls passage in the synapse. The software presents the biological structure and the physiological process through graphics, animation and short written explenations. Students were able to check themselves with a self-assessment test.The pilot study lasted 8 periods in a sequence of classroom-laboratory activities. The study was carried out in order to identify the issues regarding the implementation of a tutorial software in an existing curriculum and teachers' and students' behavior and needs. In our presentation we shall relate to the biological content,to the logistic problems of implementation and we will present a short naturalistic evaluation.

BELIEFS OF K-12 SCIENCE TEACHERS ABOUT SCIENCE TEACHING AND THE USES OF COMPUTING TECHNOLOGIES

B5-3a-2

Patricia E. Simmons, Randy McGinnis, Mary Atwater, Larry Hatfield, John Olive, and Anita Hunt, University of Georgia

The objective of this study was to gather information about the beliefs of K-12 teachers toward the use of computing technologies in instruction and toward science teaching. The Survey of Usages of Computing Technologies in Science and Mathematics Teaching was designed and administered to 122 elementary and 30 secondary teachers. Secondary teachers believed that the most important teaching activities included having students ask questions about the meaning of science concepts, providing opportunities for students to develop their own explorations in science, and applying scientific methods to problem-solving and to real world problems. More than half of the secondary teachers indicated that they never used computers to solve problems or to gather and analyze data. The elementary teachers believed that the most important teaching activities included having students ask questions about the meaning of science concepts, teaching science through exploration, encouraging students to develop their own explorations in science, and applying scientific methods to problem-solving and to real world problems. More than sixty percent of elementary teachers felt that the use of computers in their classrooms would improve science instruction, would help develop science concepts, would help students visualize science concepts, and would help improve students' attitudes toward science.

RELATIONSHIPS BETWEEN SCIENCE MUSEUMS AND SCHOOLS. REVIEW OF THE LITERATURE. B5-3a-3

Isabel Chagas, Boston University

This paper focuses on research literature with respect to the different modalities of science museums, their implications for science education, and the possible relationships between these institutions and schools. Globally, research studies reveal that visitation to museums stimulate student interest in science and increase their enthusiasm for learning more about science. Science centers have accumulated resources that, in general, are not part of the school's inventory, and they have human resources that create good conditions for the creation of innovative programs with implications in the science curriculum. This review provides basic information for the development of a collaboration model between the agencies of formal education and science museums.

B5-3a-4

SCIENCE AND MATHEMATICS CURRICULUM RENEWAL THROUGH MICROCOMPUTER INFUSION: AN EXPERIENCED TEACHER'S PLANNING PROCESSES IN A NOVEL SITUATION

David F. Jackson, Lee Meadows, and Gwen Scoates, University of Georgia

This is an exploratory case study of a master science teacher's decision-making processes concerning curriculum and teaching when afforded an unusually open-ended opportunity for innovation. Our primary focus is on the dynamics of planning for the infusion of microcomputer-based activities, particularly regarding the relative merits of different classroom organization structures. The informant is also faced, for the first time, with the additional challenges of teaching classes composed uniformly of previously low-achieving students and of shaping an integrated science and mathematics curriculum on an ad hoc basis. The nature of planning for computer use can thus be compared and contrasted to the same teacher's approach to other issues. Participant observations, audiotaped teacher journals and semi-structured interviews are the primary data sources for this ongoing project conducted in three middle school (sixth grade) classes. We hope that this session may serve as a forum for discussion of case study methodology and teacher-researcher relationships as well as of the several interrelated issues in science education which are directly addressed.

B5-3a-5

POSTER SESSION: SCIENCE & EDUCATION - A NEW JOURNAL FOR RESEARCH ON THE CONTRIBUTIONS OF HISTORY, PHILOSOPHY, AND SOCIOLOGY OF SCIENCE AND MATHEMATICS TO SCIENCE AND MATHEMATICS EDUCATION

Michael R. Matthews, Auckland University

This session will examine the first two issues of the new journal Science & Education: Contributions from History, Philosophy and Sociology of Science and Mathematics. The connection of the journal to the International History, Philosophy and Science Teaching Group will be explained, including its relation to the second conference of the group to be held at Queen's University, Kingston, Ontario, May 11-15, 1992. An account will be given of recent research in these fields, and some indication made of areas yet to be explored. Ways in which the new journal can better contribute to the improvement of college and school science and mathematics education will be canvassed.

B5-3a-6

THE EFFECTS OF SLIDE/SOUND COMPUTER-BASED INSTRUCTION ON SCIENCE STUDENTS' ACHIEVEMENT AND RETENTION.

Pierce Farragher, University of Victoria and Ron Pauline, Gannon University

Previous studies have documented the effectiveness of feedback in improving students' achievement, but few studies have examined the effectiveness of summaries or reviews. This study examines the respective and combined effects of feedback and review on students achievement, retention, and level of cognitive development. A total of 85 ninth-grade students comprised five treatment groups which received an interactive slide/sound computer earth science lesson on "The History of the Earth". All groups received 26 self-test questions throughout the program. The control group received no feedback to their responses to the self-test questions, and no reviews for each of the seven sections of the program. One group received non-content feedback for the responses and no reviews, a second group received content feedback and no reviews, a third group received non-content feedback and reviews, and the fourth group received content feedback and reviews. The students were randomly assigned to one of the five treatment groups which varied along a feedback/review complexity range. All subjects were given a 28 item achievement test immediately following the computer treatment and the same achievement test one week later.

B5-3a-7

TEACHERS' PERCEIVED NEEDS FOR IMPLEMENTATION OF COMPUTER GRAPHICS AND NETWORKING

J. Preston Prather and Glen C. Bull, University of Virginia

Invention of moveable type enabled mass production of academic materials; but integration of graphics into texts was costly and difficult. Typically, texts made reference to complex concepts but lacked illustrations to help students grasp the concepts. Metanalysis of studies over the past 30 years documented gains in learning produced by use of relevant illustrations in texts. Graphics User Interface (GUI) technology for microcomputers makes possible the economic creation of original, illustrated instructional materials through desktop publishing. Analog-to-digital converters make simulations available for analysis of real-world phenomena. Computer-telecommunications networks enable teachers to collaborate with peers. However, access to technology does not guarantee its use. Many teachers need help to realize the new instructional potential available to them. This project investigated perceived needs of selected science teachers for use of instructional technology.

Poster Session: Teaching Strategies
B5-3b

B5-3b-1

AN EXPERIMENTAL INVESTIGATION OF COOPERATIVE LEARNING AND CONCEPT MAPPING IN THE MIDDLE SCHOOL

Diana C. Rice, District 5 of Lexington and Richland Counties, and Joseph M. Ryan, College of Education, U. of South Carolina

Achievement differences related to cooperative group learning compared to regular individual student classroom structure is studied for five classes (N=120) of seventh grade Life Science, across five units of instruction. Unit level achievement is measured using traditional objective-format tests as well as concepts maps scored numerically on several criteria. Psychometric properties of the instruments are examined in detail and compared. Correlates of unit level achievement are studied and include criterion-referenced and norm-referenced tests in various subject areas and students' background characteristics. Instructional differences are tested using a two-way split plot analysis of variance, classes as between-subjects and achievement after each unit as within-subjects factors. Work is in progress Fall 1991.

B5-3b-2

AN ANALYSIS OF SCIENCE METHODS TEXTBOOKS DESIGNED TO PREPARE SECONDARY SCHOOL SCIENCE TEACHERS.

Philip R. Pankiewicz, SUNY College at Cortland

The purpose of this study was to evaluate the four most popular and current secondary science methods textbooks to determine their effectiveness in preparing secondary school science teachers. Evaluation was achieved by rating the textbooks on a seven-item Likert scale instrument designed by the author and derived from NSTA recommended guidelines for the preparation of secondary school science teachers. Three groups evaluated the textbooks: a group of college science and science methods professors, an undergraduate science methods class, and a graduate science methods class. Results revealed that all four texts were effective in meeting most of the NSTA standards but that they needed improvement in a few specific areas. All three evaluation groups also chose one of the four textbooks as being superior to the others.

"WHY DID WE SPEND ALL THIS TIME WRITING AND ARGUING IF YOU ALREADY KNEW THE ANSWER?"
THE ROLE OF TALING AND WRITING-TO-LEARN IN SCIENCE

B5-3b-3

Kathleen L. Peasley, Michigan State University

Research questions explored in this ethnographic study on the way in which oral and written discourse can be used as tools in learning science included: a) How do the students perceive classroom talk and writing in science prior to instruction? What are the norms that are already established by the fifth grade? b) What types if activities are necessary to help students think about the discourse in science in different ways? How are new norms established? and c) What type of classroom community and social context is necessary for teaching using a social constructivist framework which places emphasis on discourse as learning tools? How is this community established?

Results of this study, in which a university researcher taught science in a fifth grade classroom while the classroom teacher took fieldnotes and ran audio and video equipment, show that although both oral and written discourse can be powerful tools for helping students understand science, the existing norms for classroom talk and writing, which are typically for the purpose of teacher evaluation of student knowledge in science, must change. The data indicate that these norms can only be changed gradually and through many discussions with the students

B5-3b-4

EFFECT OF FOUR INSTRUCTIONAL STRATEGIES ON INTEGRATED SCIENCE PROCESS SKILL ACHIEVEMENT OF PRESERVICE ELEMENTARY TEACHERS HAVING DIFFERENT COGNITIVE DEVELOPMENT LEVELS

George E. O'Brien, Florida International Univ.
and Joseph M. Peters, Univ. of West Florida

Two instructors with 7 classes and 165 students were in this study. The purpose of the study wa to examine the effect of cooperative learning techniques and instruction with MBLs on the achievement of preservice elementary teachers (with different operational levels of cognitive development) in acquiring integrated science process skills and enhancing formal thinking abilities. All students were pre and post-teste with two instruments: the Test of Integrated Process Skills (TIPS & TIPS II) and the Test of Logical Thinking (TOLT). Results showed that greater differences in the achievement on the TIPS test occurred in the setting where cooperative learning and MBLs were used. Students with formal and nonformal operational levels of development scored similar gains on the TIPS and TOLT tests.

CRITICAL INCIDENTS IN THE HIGH SCHOOL LAB:
THE STUDENTS' PERSPECTIVE

Jane O. Larson, University of Colorado

B5-3b-5

This study attempts to relate investigations of student mediation of instruction to researchers' concerns about the value of the laboratory in the high school science curriculum. The Critical Incident Technique (Flanagan, 1954) is a post hoc procedure for analyzing and synthesizing descriptions in order to isolate behaviors and conditions related to the success or failure of performances. Approximately one hundred high school students completed open-ended questionnaires including anecdotal descriptions of laboratory experiences which they considered successful and unsuccessful. These observations have been classified into pertinent behaviors and conditions related to success and failure of the teaching/learning process in the lab. The final step, formulation of critical requirements for laboratory instruction, is underway. Although the Critical Incident Technique does not presuppose categories of responses, it is expected that final analysis will reveal useful information in the general areas of meaningful lab activities, characteristics of student tasks, and effective instructional techniques.

B5-3b-6

USING DRAMA AS A MEDIUM FOR TEACHING SCIENCE

Rebecca Pollard, JoBeth Gonzales, Katherine Friedrich;
Texas A&M University

Conceptual learning, in which students are encouraged to relate presented information to prior learned knowledge and experience has emerged as a major theme of science education reform. A creative drama program, developed as a Space Education Outreach project of the Space Grant Consortium, was developed to facilitate the presentation of abstract conceptual subject matter in a manner that is both relevant to past experiences and concrete in nature. Through this grant, a study was conducted to evaluate the effectiveness of drama as a science teaching strategy. A forced choice, paper and pencil test was developed, piloted and used as the dependent measure to assess the knowledge of fifth graders after they received three integrated science and drama lessons. Preliminary findings of an ANCOVA show that drama was effectively used as a strategy for teaching abstract concepts of science and concepts and techniques of creative drama.

Poster Session: Teacher Perception/Knowledge
B5-4

B5-4-1

A RECURSIVE DENDROGRAPHIC METHOD OF REPRESENTING COGNITIVE STRUCTURE BASED ON RESPONDENT'S NARRATIVE USING SCIENCE CONTENT.

Olive J. Demetrius[1] and O. Roger Anderson,
Columbia University Teachers College, N.Y. and
[1]Middle School 172 Floral Park, N. Y.

A new method of representing structure of information, elicited from students by interview, is presented and descriptive data are given for a range of multicultural students in an urban middle school. The method is related to current cognitive scientific theory and yields a visual map of the flow of ideational thought, and the relational linkages made by the respondent. The map, called a recursive dendrogram, summarizes the sequence of concepts presented by the respondent, their ordinal position in the narrative, and their logical linkages to other ideas presented in the discourse. Quantitative summaries can also be made of the organization of ideas in the map and these are used to compare results across students.

B5-4-2

DOMAIN-SPECIFIC EFFICACY IN PRESERVICE ELEMENTARY TEACHERS

Ed Gosnell, Converse College, Spartanburg, SC 29302

A teachers' sense of efficacy is considered to be the "belief in their ability to have a positive effect on student learning." Past research has failed to adequately consider two essential aspects of the teacher efficacy construct: efficacy among preservice teachers and whether, in fact, teacher efficacy is domain specific. That is, when considering the different subject areas a preservice elementary teachers will be required to teach, do they enter the classroom demonstrating a sense of efficacy stronger for one specific subject or do they hold efficacy beliefs which are of equal strength across all subject areas taught? The purpose of the present study was to construct and validate an instrument designed to address the domain-specificity of efficacy. Results indicate the Domain Specific Teacher Scale to be an effective instrument in the measurement of efficacy related issues.

THE PERCEPTIONS AND SPECIAL CONSIDERATIONS OF EXPERIENCED TEACHERS ABOUT MANAGEMENT AND DISCIPLINE: A QUALITATIVE INVESTIGATION. **B5-4-3**

Mark S. Latz, Oregon State University

The purpose of this investigation was qualitatively investigate experienced science and mathematics teachers' perceptions and special considerations about classroom management and discipline. The sample consisted of 32 experienced science and mathematics teachers that came from both small rural schools and large metropolitan districts. The teachers reacted to an open ended questionnaire that asked them to define both classroom management and discipline, and to state what they considered to be the most important considerations in each of these areas. A systematic qualitative analysis of the subjects' responses resulted in four categories for classroom management and two categories for discipline. The teachers' special considerations in both of these areas were highly variable and not conducive to the same systematic analysis. However, there were some considerations expressed repeatedly by many of the subjects. Unlike previous studies utilizing preservice teachers, the experienced teachers were able to make the distinction between the global nature of classroom management and the more focused character of discipline. In addition, experienced teachers desired long range outcomes for their students, which was not apparent with preservice teachers.

B5-4-4

SCIENCE EDUCATORS USE OF THE CONCEPT OF BELIEF

Thomas R. Koballa and J. Steve Oliver, The University of Georgia

Qualitative data collected from science education leaders (N=15) were analyzed to determine if shared meaning for the concept of belief exists among current lines of science education research that are guided by the constructivist perspective. Telephone interviews to gather more detailed information from respondents are in progress. Eight categories of definitions emerged from the data. The categories were based on common elements found in the respondents' individual definitions and emerged from the data. To some degree the common elements reflected the respondents' professed cognitive-affective orientations. The respondents' statements suggest that along with some degree of shared meaning, several different conceptions of belief exist among current lines of science education research.

A STUDY OF TEACHER EFFICACY, KNOWLEDGE OF ADOLESCENTS' CHARACTERISTICS AND ORGANIZATION OF SCHOOLS.

B5-4-5

Martha S. Waldon, University of Toledo

This study is research in progress for the completion a doctoral dissertation. It will identify variables that affect the efficacy of teachers that teach grades six through eight in the middle school or junior high settings. Previous studies have indicated that teachers' perceptions of their ability, and the ability of the teaching profession in general, have an effect on what and how they teach. Understanding what variables affect the efficacy of teachers will be of future assistance in maintaining or raising levels of efficacy. Since past experiences have a major effect on efficacy two variables are studied. The relationship between the teacher's personal efficacy and two distinct variables; the teachers knowledge of adolescent's characteristics and the teachers' perceptions of organizational support are investigated. After determining the teachers' personal and general efficacy levels using the Teacher Efficacy Scale developed by Gibson (1982), the teachers rated their perception of support within the organizational structure of the school system. They identified statements of adolescent characteristics using a likert scale. This data will subsequently identify significant variables correlated with the efficacy of middle school teachers.

B5-4-6

ELEMENTARY TEACHERS' PERCEPTIONS OF FACTORS INFLUENCING HIGH SCIENCE TEACHING SELF-EFFICACY.

LINDA RAMEY-GASSERT, Kansas State University

Scores on the Science Teaching Efficacy Belief Instrument (STEBI-A)(Riggs, 1988) gathered from 28 master teachers indicated that three of the elementary teachers were highly efficacious in the area of science teaching. The STEBI - A was used to assess the personalself-efficacy (PE subscale) and the outcome expectancy beliefs (OE subscale) components of science teaching self-efficacy. The purpose of this study was to gain insight as to what factors these three master teachers perceived as contributing to their being identified as highly efficacious science teachers. Probing questions were generated using information from questionnaires and surveys administered to the entire group to identify key factors (e.g. significant people/teachers, family, courses, meaningful events or experiences, interests, personality characteristics, learning styles, etc.) which fostered their affinity for science teaching. Using qualitative methodology, open-ended interviews with the three teachers further clarified relationships between their high score on the STEBI-A and their perceptions of what facilitated their development into efficacious science teachers. Several interesting trends were noted. Further analysis and triangulation of the interview data continues to reveal perceptions and insights which may have potential impact on teacher inservice and preservice teacher training, and possibly significant impact on formal and informal science education as a lifelong learning experience.

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THE EVOLUTION OF PRESERVICE SCIENCE TEACHERS' CONCERNS ABOUT TEACHING

Edward J. Zielinski and Denise Preston,
Clarion University of Pennsylvania

B5-4-7

The purpose of this study was to determine the evolution of preservice science teachers' concerns at a traditional institution. Students were pre and posttested with a valid modified Stages of Concerns Questionnaire. Mean scores were calculated and plotted. Freshman began with peak concerns in the informational area which were not resolved that year. Sophomores began with informational concerns and ended with consequence concerns. Juniors began with informational and ended with consequence concerns. Science methods students, with field experience began with information and consequence concerns and ended with lower information and high consequence and refocusing concerns. The student teachers began with peaks at the consequence and refocusing stages. Student teaching elevated these concerns and lowered the management concerns. Collaboration concerns were also elevated.

B5-4-8

Design of an Instrument to Assess Science Teachers' Teaching Strategy Choices.

Catherine G. Yeotis and Linda Bakken,
Wichita State University

The purpose of the study was to design an instrument which would assess elementary teachers' teaching strategy choices in the teaching of science concepts. Currently, there are three major educational approaches, relying on three different approaches on how children learn: The 'clean slate' perspective; the 'flowering seed' view; and the 'interactive generator-transformer' approach. Recent research supports the interactive generator-transformer approach as the most conducive to effective learning by students. The Teaching Strategy Choices questionnaire designed specific sample teaching situations which addressed one of the three major educational teaching strategies. A pilot test correlating the Teaching Strategy Choices questionnaire with a reliable and adequately validated perceived science teaching self-efficacy survey approached a significant relationship.

B5-4-9

AN EXPLANATORY MODEL OF STUDENT PERSISTENCE IN A PRESERVICE SCIENCE AND MATHEMATICS TEACHER EDUCATION COURSE.

Keith B. Lucas and David F. Tulip, Queensland University of Technology, Australia

The purpose of this study was to establish factors which distinguished 'persisters' from 'withdrawers' and to examine the manner in which selected factors influenced students' persistence in the first semester of a preservice teacher education course for science and mathematics teachers. Data were collected via a questionnaire designed by the authors and previously published instruments which measured academic locus of control and several dimensions of self concept. In an initial analysis, no consistent gender effects were evident. Consequently, data for male and female students were pooled. Discriminant analysis was employed resulting in a discriminant function involving seven factors which correctly classified 81% of cases. Results indicated that academic locus of control, expectation of academic integration, influence of family and friends and personal aspirations are likely to be important factors in students' decisions to persist or withdraw. A theoretical model indicating hypothesised patterns of effects was proposed and will be tested using the LISREL 7 program. Implications for course administrators and academic advisers are discussed.

B5-4-10

CONCEPTIONS OF TEACHING SCIENCE HELD BY EXPERIENCED HIGH SCHOOL SCIENCE TEACHERS

Peter W. Hewson, Perry A. Cook, and Holly Walter Kerby, University of Wisconsin-Madison

The purpose of this study was to describe the nature of the conceptions of teaching science held by a sample of experienced high school biology, chemistry, and physics teachers. Fourteen high school science teachers were interviewed using the Conceptions of Teaching Science Interview and the transcripts were analyzed into categories of nature of science, nature of learning and the learner, rationale for instruction, preferred instructional strategies, and teaching science to determine their conceptions of teaching science. The results showed that, while in general individual conceptions of teaching science were internally consistent, there were considerable differences between teachers with respect to the content of different analysis categories and in the relative emphasis between categories.

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TEACHER KNOWLEDGE, CONCEPT MAPS, AND VEE DIAGRAMS: WHAT DO SCIENCE LESSONS REALLY MEAN?

Patricia Kerr, University of North Dakota

B5-4-11

This study reports on the use of concept mapping and Vee diagramming for science teaching by teachers of grades 4-9 during and after attending Eisenhower summer workshops, 1991. Thirty-seven teachers were taught the theory supporting concept mapping and Vee diagrams for meaningful learning, and using their own favorite science activities, practiced the processes involved in implementing the heuristics for science learning. Recognizing that science knowledge construction and learning science concepts are closely related, the teachers expressed greater confidence in assuming a role of being a science learner along with their students. Helping teachers understand the meanings of the lessons they were already teaching by using these strategies encouraged those who felt their content knowledge was inadequate. After proposing a plan incorporating concept mapping and Vee diagrams for their fall science curriculum, the teachers reported on the efficacy of using the strategies, both for them and their students.

B5-4-12

BUILDING A KNOWLEDGE/SKILL BASE BY ENGAGING IN TAKING, CRITIQUING, AND CONSTRUCTING OF ASSESSMENT ITEMS: A FEASIBILITY STUDY, L. Barnes and M. Barnes, University of North Florida

A crucial variable operating in the school setting is the involvement of teachers in the development process. Ownership and meaningfulness are essential to the development of an idea, strategy or a curriculum. The process which begins in methodology classes extends to requiring students to experience and to critique various assessment modes. The purpose of this study is examine the effects of involving teachers in building their own knowledge/skill base with regard to assessment. The sample consists of twenty students in elementary science methods and nineteen students in secondary on general science knowledge and skills. Students analyze their responses and critique the instruments to decide on the particular kinds of knowledge and/or skill being assessed. Profiles of the two classes include correlation of demographic data with response patterns.

A STUDY OF THE SCIENCE SKILL ACHIEVEMENT OF PRESERVICE ELEMENTARY TEACHERS. L. DeTure, and N. Escudero, Rollins College

B5-4-13

The purpose of this study is to investigate preservice elementary teachers' level of performance of science process skills using practical laboratory assessment measures and to determine the effects of the methods class on the acquisition of skills.
Pretest and post data for preservice teachers was gathered and examined using both the content test and the practical laboratory skills tests developed for the Second International Science Study (SISS). The tests were administered to two graduate groups (35 Students) and two undergraduate groups (34 students) of preservice teachers. On the pretests teachers scored significantly higher on the process tasks (80%) than did comparative samples of students (55%) in grade 5. For the grade 9 level tests, preservice teachers scored generally higher (66%) than the grade level students (60%). Student performance on grade 5 tasks was generally high for the pretest and there was no significant change on the post test. On the Grade 9 tasks, students scored significantly higher on each of the tasks.

B5-4-14

Science Teacher Decision-Making In A Multicultural Classroom.
J. Randy McGinnis, The University of Georgia.

The purpose of this study in progress is to investigate science teacher decision-making with students of diverse populations. A qualitative methodology is used to investigate pedagogical decision-making used by two teachers in two multicultural classes. A descriptive narrative of the process of pedagogical decision-making used by the teachers during interactions with various student populations is the focus of this study.

A constructivist knowledge theory will provide the framework for interpreting the decision-making process of the "abstracted curriculum." The abstracted curriculum is defined as a model created as a result of participation in ongoing teaching and learning. Assertions constructed by the researcher will contributetoward the formation of strategies to more successfully teach multicultural classes.

Poster Session: Student Attitude/Knowledge
B5-5a

B5-5a-1

GENDER DIFFERENCES IN PREDICTING 10th GRADE STUDENTS' ATTITUDES TOWARD SCIENCE: RESULTS FROM THE LONGITUDINAL STUDY OF AMERICAN YOUTH (LSAY)

Andrew T. Lumpe, Ronald M. Krestan, Wang Jianjun,
Center for Science Education, Kansas State University

The researchers' purpose was to determine the influences of various student, peer, and parental factors on American 10th grade students' attitudes toward science. The subjects used represent a national probability sample and were sorted by gender for the stepwise regression analysis. The best predictor of girls' positive attitudes toward science was an Issue Interest scale (explaining 10% of the variance). The best predictor for boys was a Science Achievement test (explaining 10% of the variance). Other predictors remaining in the regression models for both sexes include: Peer Math and Science Push, Independence/Persistence, Parent Science Push, Parent Math Push, Attitude Toward Math, Family Communication, Math Achievement, Self-Esteem, and a Implications of Science for Society test. These remaining variables explained an additional 14% of the variance for girls and 19% of the variance for boys.

B5-5a-2

Chemcom in Socio-Cultural Context: Interdisciplinary Analysis of a Science-Technology- Society Curriculum

William S. Carlsen, Christine Cunningham and Gregory Kelly,
Cornell University.

In this paper, we scrutinize a popular Science-Technology-Society curriculum using four sociocultural themes. These themes are: 1) the sociology and politics of scientific judgment, 2) the political economy of science, 3) expertise versus democracy in public decision-making, and 4) the place of individual ethics in the conduct of science. Our curricular focus is ChemCom: Chemistry in the Community, a commercially successful and scientifically respectable S-T-S program. We report on ongoing analysis of ChemCom in two instructional settings: a graduate seminar in science education and a year-long experiment teaching ChemCom to non-college-bound public school students. Preliminary findings of these projects: a) The curriculum emphasizes the sociology of political decision-making without acknowledging the sociology of scientific decision-making; b) Political deliberations in the curriculum are framed in ways that promote the interests of the chemical industry; c) Science and technology are presented as vital and necessary expenses, rather than as variables in a political economy, d) Scientific authority is given special status in simulated political discourse, and e) Ethical decisions of individuals are treated only superficially.

LIFE SCIENCE STUDENTS' RESPONSES TO QUESTIONS ABOUT PLANTS: AVOIDANCE STRATEGIES IN CHILDREN.

Delena Tull, University of Central Arkansas

B5-5a-3

232 life science students were asked to identify plants seen in a set of slides. When the students did not know the correct common name for a plant (e.g., oak) they relied on a variety of alternate response types. The patterns of response used by students were examined. The patterns suggest avoidance strategies: avoidance of an abstract name, avoidance of admission of ignorance, and avoidance of being wrong. The responses did not result in names that would be acceptable to a science teacher, but various strategies had the effect of hiding the students' lack of knowledge and preventing a "wrong" answer. Relationships were examined between the avoidance strategies and ethnicity, gender, achievement test scores, and environmental background of the student (judged by preference for indoor or outdoor play and rural or nonrural living environment).

B5-5a-4

The Attitudinal and Cognitive Effects of Planetarium Integration in Teaching Fourth, Fifth, and Sixth Grade Students

Dr. Mark Twiest, Indiana University of Pennsylvania

The purpose of this study was to investigate the attitudinal and cognitive differences among students in an astronomy curriculum which utilizes a planetarium in comparison to an astronomy curriculum which is presented solely in the classroom. The specific attitudes of interest in this study are those student attitudes toward science in general and towards astronomy as a specific subject area. Researcher designed attitude and astronomy achievement measures were developed and administered to 423 fourth, fifth and sixth grade students in three schools. Pre and post test data were collected from students in this quasi-experimental design. Two way analysis of co-variance techniques were used to analyze the independent variables of gender and treatment. Results revealed significant differences ($p<.05$) in student attitudes toward astronomy in the fourth grade favoring the experimental school students. Significant differences ($p<.05$) in student achievement favoring the control school students were found in the fourth and fifth grades with respect to knowledge level questions. Significant differences ($p<.05$) in student achievement were found for comprehension level questions at every grade level. The control school students outperformed the experimental setting in the fourth and sixth grades. Fifth grade experimental setting students had significantly higher achievement on comprehension level questions.

A REVIEW OF ATTITUDE AND BEHAVIOR STUDIES IN ENVIRONMENTAL EDUCATION: IMPLICATIONS FOR FUTURE RESEARCH

B5-5a-5

Barbara S. Babineaux, Melissa Tothero, and Frank E. Crawley, The University of Texas at Austin

The purpose of this paper is to provide an updated, systematic review of studies in environmental education dealing with attitudes and behaviors since 1983. More than 40 studies were located by an ERIC search and manual searches of relevant journals. Studies were selected in which an actual assessment of attitudes or behaviors was made. About 50% of the studies were descriptive and assessed general attitudes. Many studies lacked clarity and showed little awareness or use of findings/models from the socio-psychological fields. The use of proven instruments and measures of long-term change and locus of control/responsibility in a few studies was encouraging.

B5-5a-6

THE FOCUS OF FEMALES AND SCIENCE RESEARCH: AN ILLUSTRATION OF BLAMING THE VICTIM

Sharon Parsons, San Jose State University

The issue of the under representation of females in science has recently received a lot of attention. Most of the research however has largely focused on explaining gender differences on standardized achievement tests and/or on environmental differences. Such research presents a deficiency model which views females and/or their environment as being deficient. A more powerful analitical position might be the viewing of science itself as being deficient. The constructivist view of knowledge provides a basis for making such an argument. Specifically, it might be helpful to draw upon a sub-section of the more general constructivist position, the social construction of knowledge. Evelyn Fox Keller (1985) argues that not only are gender and science socially constructed but that science is socially constructed in a masculine image. This paper through an illustrative case study will examine why research has focused on correcting a female deficiency rather than examining the broader issue of the nature of science.

PREDICTING STUDENT SUCCESS IN INTRODUCTORY CHEMISTRY. THE ROLES OF MOTIVATION AND PAST ACHIEVEMENT

B5-5a-7

Brian P. Coppola, *The University of Michigan*

In this study, we selected two populations of students from the new first-year chemistry course at The University of Michigan, based on their performance after one term: those who consistently inclined and those who consistently declined on their four examinations. Traditional predictors for success do not correlate with student performance in this class. Instead, the results from interviews conducted with the Incliners and the Decliners indicate a correlation with some aspects of the Attribution Theory of Motivation. In addition, there is an indication of a reversal in the usual gender bias in these two groups, where men are overrepresented in the group of Decliners. A quantitative assessment for using a *Learning Strategies and Motivation Questionnaire* as a placement instrument will be discussed.

A QUANTITATIVE DESCRIPTION OF ELEMENTARY STUDENTS' ACTIVITIES DURING PHYSICAL SCIENCE LABORATORY LESSONS

B5-5a-8

Bambi L. Bailey and Jane Butler Kahle, Miami University, Oxford

One of three types of physical science inservice workshops, content skills, equitable pedagogy, and a combination of both was presented to 24 fourth and fifth grade teachers ina Midwestern, urban/suburban school district in order to investigate whether any or all of the three types of inservice workshops would result in greater manipulation of physical science equipment by female students. After surveying the teachers, it was found that topics of electricity and simple machines were topics that teachers least preferred to teach. Therefore, these topics were the content areas included in the fall and spring inservice workshops, respectively. One week later, teams observed the activities of students in classes taught by the participating teachers. Two observations were conducted in the fall semester; one in the spring semester. The purpose of the spring semester inservice workshop and observation was to evaluate any longevity of differences in the female students' manipulative activities.

STRESS ON THE ROLE OF EVIDENCE AS A BASIS OF KNOWLEDGE CLAIMS IN SCIENCE AND CONTROL BELIEF IN ELEMENTARY SCHOOL CHILDREN

B5-5a-9

John Butler, University of Michigan (student)
and Anchorage, Alaska School District (teacher)

The purpose of this study was to measure any gains in control belief of elementary school children, intention to act to resolve problem situations and greater belief in and use of evidence as basis of knowledge claims in science. The 350 sixth grade students participated in 45 lessons over a fifteen week period in which the role of evidence as a basis of knowledge claims in science was emphasized by the twelve classroom teachers. Three measurements were used: 1. a paper and pencil pretest-posttest 2. interviews of students before and after and 3. ongoing objective observations. Results of the pilot study indicate positive trends in control belief, intention to act and use of evidence.

Poster Session: Inservice Program Evaluation
B5-5b

B5-5b-1

ACTION PLANNING FOR EARTH SCIENCE FIELD TRIPS: REDUCING THE BARRIERS

Larry Enochs, Peggy Daisey, Ron West, and Tom McCahon, Kansas State University

Action planning was used as a tool for reducing barriers to earth science field trips with 50 middle school science teachers, who were involved in summer institutes sponsored by a National Science Foundation Teacher Enhancement grant. Action planning was defined as a process by which a teacher plans for a change by considering the context of the change. Some of the barriers included lack of planning time, lack of resource people for assistance, lack of funding and lack of preservice preparation in the necessary skills. Assertions were made about the teachers' action plans. These assertions were validated through the teachers' action plans (which were written in the summer before their proposed field trips) and their responses to an end-of-the year survey. Overall, the teachers found that action planning reduced the barriers to field trips, as well as empowering them to provide students with the opportunity "to do" geology.

B5-5b-2

A NATIONAL SCIENCE FOUNDATION PRE-COLLEGE TEACHER ENHANCEMENT PROGRAM FOR MIDDLE/JUNIOR HIGH SCHOOL LIFE SCIENCE TEACHERS.

Melissa A. Warden, Ball State University; Thomas R. Koballa, Jr., University of Georgia; and Lowell J. Bethel, University of Texas at Austin

This paper discribes the operation and in-progress evaluation of a recently completed three year program sponsored by the National Science Foundation to enhance the teaching effectiveness of less-well prepared middle and junior high school life science teachers. A series of instruments designed to quantify the program's overall success revealed that participants significantly improved their biological content knowledge and their attitudes toward teaching science using inductive strategies. Participant intentions to use at least 50% of the activities and investigations developed over the course of the program with their own students were later shown to correlate positively with observed behavior. Evaluation is continuing using qualitative techniques to assess the program's impact on the maintenance of such change in teaching behavior over time.

A STATEWIDE MODEL FOR MIDDLE SCHOOL SCIENCE IMPROVEMENT

B5-5b-3

Burton Voss and David Kazen

The Science Education in the Middle School (SEMS Project) was an attempt to bring together a Statewide University Consortium, a State Department of Education, and Middle School teachers and administrators to enhance the preparation of out-of-date, out-of-field middle school science teachers. To enhance the preparation of these teachers the Consortium developed a SEMS Manual consisting of teaching resources, pedagogical techniques, and science labs. Science updates were held for underprepared teachers, and a cadre of excellent middle school teachers were prepared with a variety of approaches to assist the targeted teacher population. Results from mail surveys and site visits provided positive ratings for the project in terms of providing teachers with increased ability to use hands-on techniques in teaching science, increasing teacher knowledge about science, and providing teachers with greater resources and science-related contacts.

B5-5b-4

THE EFFECTS OF AN STS ISSUE INVESTIGATION AND ACTION TRAINING SUMMER INSTITUTE ON MIDDLE SCHOOL SCIENCE TEACHERS

Patricia R. Simpson, St. Cloud State University

The purpose of this study was to determine the effects of an STS issue investigation and action training summer institute on 1) participation in actions taken on STS issues, 2) perceived knowledge of STS issues, 3) science process skills, and 4) science content achievement. Pre and post test scores from the 24 participants were analyzed for any significant change. Results indicated the institute was effective in enhancing participant's perceived STS knowledge, science process skills, science content and some components of action. Additional information will be presented from teacher evaluations and interviews conducted once teachers had an opportunity to use information gained in the program with their students.

B5-5b-5

1991 NEVADA SCIENCE PROJECT: AN APPRAISAL OF A SUMMER INSTITUTE FOR NEVADA SCIENCE TEACHERS.

William J. Pankratius and Richard Powell, University of Nevada, Las Vegas and Michael Robinson, University of Nevada, Reno.

The objective of this investigation was to examine the effects of a summer program on the attitudes and teaching strategies of twenty-five participating science teachers. The teachers took part in a 10 day institute during which they attended content presentations, took field trips, investigated current topics in science education, engaged in concept mapping, and worked in teams in order to create activities and curricula pertaining to the subjects under study. The teachers were surveyed as to their beliefs on scientific literacy immediately before and after the program. Toward the end of the program, each participant underwent a thirty minute structured interview conducted by an independent evaluator not associated with the project. Finally the participants were surveyed as to the effects of the program at three and six month intervals. Tentative findings indicate a trend, on the part of the participants, toward using scientific processes and the application of scientific information combined with a trend away from an emphasis on scientific facts and definitions.

B5-5b-6

LONG-TERM EFFECTS OF NSF-SPONSORED SUMMER INSTITUTES

Lisa McWhirter, Edmund Marek, and Ann Cavallo
University of Oklahoma

The purpose of this study was to investigate the long-term implementation of laboratory based science curricula (learning cycles) as it relates to 1) student and parent reaction to the curricula, 2) administrative and peer support, 3) preparation time, and 4) diversity of teaching assignments. Month long in-service programs, funded by the National Science Foundation, were held in the science laboratories of the local high school during each of the three consecutive summers from 1987 to 1989. Science programs which were examined during the summer institutes were titled: Investigations in Natural Science: Biology, Chemistry, Physics (1985). The summer institutes also included the examination of the educational and scientific theories upon which the curricula were based. Seventy-five master teachers, twenty-five from each of the summer institutes, were the sample for this study. The teachers were administered pre- and post- program instruments, as well as a follow-up instrument administered in 1991. The results of the three instruments were analyzed for significant change and co-relationships among the variables listed above. The implications of the study's findings for in-service science education are discussed.

B5-5b-7

EVALUATION OF A UNIVERSITY/SCHOOL-BASED, SUSTAINED CONTACT INSERVICE FOR ELEMENTARY SCIENCE TEACHERS.

Joseph P. Riley II, Mark Guy, Darwin Smith, University of Georgia and Barbara Cornelius, Clarke County School System, Athens, Ga.

The purpose of this study is to evaluate the effectiveness of a sustained-contact, field-based, inservice training model. The inservice was designed to improve the physical science content knowledge and content specific pedagogical knowledge of participating elementary science teachers.
The inservice format followed a sustained-contact model that introduced teachers to science content knowledge and pedagogy in a Summer workshop. The course instructors sustained contact with participants through the Fall quarter with a school based program designed by each of the participants. The evaluation used both quantitative and qualitative information. Preliminary results indicate that the initial phase of this sustained contact program resulted in teachers acquiring knowledge of the physical science concepts generally taught in the elementary grades. Following inservice participants into the classroom seems the most straight forward way of insuring application of knowledge and strategies learned in an inservice workshop. The results of this evaluation should provide information for judgements as to the costs and benefits of a sustained contact inservice format.

Round Table Discussion: Science Education Research
C2-1

Report of the NSTA/AAAS/NARST Task Force for Defining a Research Agenda in Science Education
Emmett L. Wright, Kansas State University

The Task Force has been in existence for the past two years. The major purposes of the Task Force are to:

1. Provide leadership through various coalitions with agencies that are concerned with the improvement of science teaching and learning.
2. Articulate parameters for science education research.
3. Summarize and disseminate the findings of science education research in a manner that is useful for both researchers and practitioners.
4. Develop effective means for the application of research to science teaching and learning.
5. Enhance quality of science teaching worldwide through research and policy development.

The specific objectives of the Task Force Report that have been accomplished over the past two years and steps planned for the future will be discussed.

Contributed Papers: Student Knowledge
C2-2

C2-2-1

MASSED VERSUS DISTRIBUTED PRACTICE IN HIGH SCHOOL PHYSICS.

Michael G. Grote, University of Cincinnati and Mariemont High School

An analysis of the effects of distributed practice versus massed practice in the study of two topics in physics was undertaken with 40 students in each of the two groups. Students received the same practice material but the massed practice group received all the practice on the same day, whereas the distributed practice group received the practice gradually over a period of one month. A repeated measures MANOVA was used to evaluate the treatment and its interaction with higher/lower performers in physics and with time over a period of 6 weeks. A significant difference in achievement was found between the groups which used distributed practice as opposed to massed practice. The effect size was .57 favoring the group having distributed practice. The effect was stable with time, and the treatment was of benefit to both high and low achievers.

C2-2-2

KNOWLEDGE IS NOT ALWAYS WHAT WE TAKE IT TO BE: ISSUES IN THE ASSESSMENT OF STUDENTS' UNDERSTANDINGS OF MOTION

Dori Ridgeway, Columbus Public Schools

A study was made of the ways in which knowledge of mechanical motion is affected by contextual factors such as means of depiction (ranging from abstract to contextualized) and of the effect of sequencing of stimuli (from abstract to contextualized or contextualized to abstract) on students' display of knowledge. The study involved forty fifth grade children in two urban, inner-city desegregated elementary schools. Results indicated that in assessing conceptions of projectile motion, 23% of the students could represent their predictions through accurate sketches, but not provide valid explanations of their predictions. Eighteen percent were able to provide valid explanations but inaccurate sketches of their predictions of projectile motion. The sequencing of the images from abstract to contextualized heightened students' ability to explain projectile motion whereas reversing the sequence heightened students' ability to represent projectile motion. As the complexity of the motion increased, the contextualized image caused more confusion than the more abstract images. One implication of this study is that the physical context in which a concept is assessed affects what is assessed. The study further implies that if multiple assessment is implemented, then care must be taken regarding the choice of depiction media, i.e. contextualized images (unenhanced) are not always the best choice for informing students who are learning.

C2-2-3

A QUALITATIVE STUDY OF PRESERVICE ELEMENTARY TEACHERS' DEVELOPMENTAL UNDERSTANDING OF ELECTRICITY AND OPTICS CONCEPTS.

Lois M. Campbell, The Pennsylvania State University and Gerald H. Krockover, Purdue University

The purpose of this study was to observe and document the thoughts and beliefs concerning physics concepts held by preservice elementary education students enrolled in a college physics course. In addition, comparative analysis was developed utilizing clinical interviews with participants from an elementary science education methods course. Through a qualitative study which utilized ethnographic methods, the researcher attempted to develop an understanding of how preservice teachers as learners construct an understanding of physics concepts and how understandings are sustained over an extended period of time (one year). It was the researcher's intent, through a phenomenological and constructivist base, to provide the reader a view of preservice elementary science education and in doing so, to "tell the stories of the participants through their voices." The results of the study indicate that these participants appeared to learn best through a variety of instructional techniques beyond the lecture method. In the final analysis of the pre- and post-interview comparisons, the participants demonstrated some conceptual changes in the understanding of physics concepts, but their constructions were still inconsistent with scientific explanations.

Symposium: Epistemology
C2-3

TEACHER AND STUDENT EPISTEMOLOGIES IN SCIENCE CLASSROOMS: PAST RESEARCH AND FUTURE PROSPECTS

Wolff-Michael Roth, Appleby College; Ken Tobin, Florida State University; James Gallagher, Michigan State University; William W. Cobern; and Anita Roychoudhury, Miami University.

The classroom is a location of complex interactions between students, teachers, curriculum, and environmental factors. These interactions are likely to be shaped by those beliefs about the world, about knowing, and about learning which both students and teachers bring with them. To construct a viable understanding of these classroom processes, we need to know more about teachers' and students' beliefs and epistemologies and how they interact during science teaching and learning. In order to promote a discussion of future research needed to elucidate the interaction of divergent viewpoints in the classroom, the presenters of this symposium report on (a) teachers' changing views of scientific knowledge prompted by student difficulties in constructing science knowledge; (b) the importance of metaphors in teachers' conceptualization of classroom contexts; (c) a comparison of biology professors' and students' conceptualizations of nature; (d) physics students' epistemologies and views of knowing and learning; and (e) the views on knowing and learning science held by students with differing epistemologies in the context of a constructivist classroom.

Contributed Papers: Scientific Knowledge
C2-4

COOPERATIVE INCENTIVES AND HETEROGENEOUS ARRANGEMENT OF COOPERATIVE LEARNING GROUPS: EFFECTS ON ACHIEVEMENT OF ELEMENTARY EDUCATION MAJORS IN AN INTRODUCTORY LIFE SCIENCE COURSE

C2-4-1

Scott B. Watson
Department of Science Education
East Carolina University

The purpose of this study was to examine the importance of cooperative incentives and heterogeneous grouping as elements of cooperative learning. Cooperative learning may be defined as a classroom learning environment in which students work together in heterogeneous groups toward completion of some task. Cooperative incentive structures provide some type of group reward based on group products or individual learning. In heterogeneous grouping, students are arranged in order to maximize variety within groups. A 2 X 2 factorial design was used in this study. The independent variables considered included (1) use of cooperative incentives in learning groups, and (2) use of heterogeneous grouping in cooperative learning groups. Dependent variables for all treatment groups were scores from an instrument developed for an earlier, related study. An analysis of covariance (ANCOVA) was used as the data analysis procedure. No significant differences were found between the treatment groups.

C2-4-2

THE CHARACTERIZATION OF SMALL INSTRUCTIONAL WORK GROUPS IN 9TH GRADE BIOLOGY.

Steven R. Rogg, University of Maine and Jane B. Kahle, Miami University

The analysis of student verbal interaction within small instructional groups is a useful technique for the understanding of group learning processes. Results of this study demonstrate that environmental or contextual group, and student characteristics modulate verbal interaction within the small instructional group. Furthermore, the quantity and quality of student verbal interaction can be expected to predict the extent to which students realize academic, social, and socioemotional gains as a result of the group experience. Fortunately, the variables "student on-task engagement", "cognition", "peer helping behavior", and "group structure" are readily characterized by studying student verbal interaction and the distribution of this interaction within the group. In this study, relationships were examined between these process-related variables and both student ability and achievement. Task engagement, helping behavior, and group structure were found to be significantly correlated with ability. It follows then, that the systematic fine analysis of student verbal interaction is a promising approach for addressing at least some of the pending questions about small instructional work groups. This study was designed to explore the utility of small group interaction analysis as both a field-based research methodology and as a classroom-based assessment procedure.

C2-4-3

TEACHING PHYSICS PROBLEM SOLVING THROUGH COOPERATIVE GROUPING: DO MEN PERFORM BETTER THAN WOMEN?

Patricia Heller, University of Minnesota

This study utilized a post-test only, no-control group design to investigate the influence of an instructional approach on the problem-solving performance of college men and women in a large introductory physics course for non-majors. The instructional approach combined the explicit teaching of an expert-like problem solving strategy with a supportive environment in which students practiced using the prescribed strategy to solve problems in mixed-ability, cooperative groups. The practice and test problems designed for the course were more difficult than most standard textbook problems. The sample consisted of 39 women and 52 men who completed both quarters of the course. Comparisons with other sections of the course indicated that the sample was representative of students who normally enroll in the course. On 22 problems given over the two quarters, there was no significant difference in the problem-solving performance of the men and women. The results suggest that high-quality educational environments can be designed which reduce the gender gap in the problem-solving performance of males and females.

Contributed Papers: Scientific Knowledge
C2-5

ETHICAL DILEMMAS IN SCIENCE TEACHING

C2-5-1

DEBORAH J. TIPPINS, UNIVERSITY OF GEORGIA; KEN TOBIN, FLORIDA STATE UNIVERSITY; KARL HOOK, FLORIDA STATE UNIVERSITY.

Our investigation into the ethical dimensions of teaching was designed to shed light on the process by which a teacher generates actions intended to resolve the many dilemmas encountered in practice. Our research has focused on the attempt to identify and interpret ethical dimensions of teacher knowledge in the context of science teaching. The purpose of the present study was to investigate the ethical dimensions of science teaching in terms of the referents, images, metaphors, and beliefs of Greg, a middle school science teacher. Our questions about the nature of ethical dilemmas were informed by a constructivist epistemology. Some of the questions investigated in the study were: what kind of ethical dilemmas can be identified in a middle school science classroom? How do these dilemmas reflect teacher knowledge? What referents does Greg use to determine whether or not particular actions/decisions are ethical in the classroom? How can we interpret Greg's choices that involve ethical conflicts from a constructivist perspective? Vignettes are used to illustrate ethical dilemmas related to issues of safety, management, and interaction involving subject matter knowledge

C2-5-2

AN ANALYSIS OF THE CONCEPTIONS ABOUT THE NATURE OF SCIENTIFIC KNOWLEDGE OF PORTUGUESE SECONDARY SCIENCE TEACHING

A.Francisco Cachapuz and J.Félix Praia, Aveiro University and Porto University

Secondary science teachers play an important role in forming the image of science that is held by their pupils. However, research suggests that quite often science teachers' conceptions of the nature of scientific knowledge are little better than of their students. In Portugal, there are no research studies which may help to characterise science teachers' epistemological views in order to design appropriate training courses. This study aims (i) to diagnose what conceptions (empiricist/rationalistic) are held by Portuguese secondary science teachers concerning the relationship between theory and observation, and about the nature of scientific method; (ii) to analyse the relationship between such conceptions, and the variables subject matter taught and professional experience. Basic data was generated by responses given by a representative sample of 464 science teachers to a questionnaire (multiple choice questions). The results showed the predominance of empiricist views (nearly 2/3 of the sample) about the two aspects investigated. Empiricist views seem to be independent of the teaching subject ($X^2 = 4.890$, $\alpha = 0.05$) and professional experience ($X^2 = 3.885$, $\alpha = 0.05$). The need for adequate training courses is discussed and suggestions concerning their design are proposed.

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INCREASING ELEMENTARY TEACHERS' ABILITY TO EXPLAIN EVENTS IN SCIENCE BY MAKING CAUSAL RELATIONSHIPS MORE EXPLICIT IN SCIENCE TEXT

C2-5-3

Rosalyn H. Gates, Indiana University of PA

This study investigated the effects of causal explicitness in science text on the quality of explanations generated by readers and their consequent performance on transfer tasks. Subjects were 156 preservice elementary teachers randomly assigned to one of four treatment conditions. The research design was a 2x2 factorial. The manipulated variables were causal explicitness in a theoretical knowledge text and causal explicitness in an applied knowledge text. Both texts explained a science demonstration involving air pressure. Dependent measures were scores on quality of written explanations and scores on transfer measures of explanation quality, prediction accuracy, and confidence rating. Results indicated that readers of causally explicit text generated significantly higher quality explanations than readers of text which lacked causal explicitness. Groups did not differ on transfer. It was concluded that causal explicitness in text facilitates readers' understanding of science.

C2-5-4

CONSTRUCTING EXPLANATORY MODELS FOR ANOMALOUS GENETIC PHENOMENA: PROBLEM SOLVING IN THE 'CONTEXT OF DISCOVERY'.

Robert S. Hafner, Western Michigan University

The purpose of this research was to examine how problem solving in the domain Mendelian genetics proceeds in situations where solvers' knowledge (or mental models) are insufficient to solve problems at hand. Such situations require solvers to use existing models to recognize anomalous data and to revise those models to accommodate the data. The study was conducted in the context of a nine-week high school genetics course and addressed the following questions: How do revised models vary with respect to objects, states and processes? Do revised models represent an increase in complexity and realism over initial models? What is the nature of model development across problem types? Six students from the course were selected and asked to solve computer-generated problems incorporating the anomalous phenomena of multiple alleles, gene interaction, pleiotropy, sex linkage, and autosomal linkage. Sources of data for analysis included: students' think aloud protocols, computer printouts of crosses performed, and any written materials produced during the problem solving process. All six students had success model-revising problem solving to produce final models of increasing complexity and realism.

Contributed Papers: Elementary School Teachers
C2-6

C2-6-1

THE EFFECT OF ASTRONOMY TEACHING EXPERIENCE ON THE ASTRONOMY INTEREST AND CONCEPTIONS OF ELEMENTARY SCHOOL TEACHERS.

Linda S. Shore, Polymer Center Education Projects,
Physics Dept., Boston University
Robert Kilburn, Science Education Program,
School of Education, Boston University

This study employed a static group comparison design to compare the astronomy interest and conceptions of two groups of elementary school teachers: an experimental group teaching an extensive astronomy unit (N=12) and controls who did not teach astronomy (N=10). Previous astronomy teaching experience and long-standing astronomy interest were confounding variables controlled in the study. Astronomy interest was measured by a nine-item multiple choice astronomy interest assessment. Astronomy conceptions were determined by analyzing a twelve-item multiple choice astronomy concepts survey. Non-parametric statistics were used in the analyses. Results showed that although teachers who taught astronomy showed significant gains in their astronomy interest compared to the controls, teachers in the experimental group did not have higher total astronomy concept scores. Furthermore, there were no differences between the types of astronomy misconceptions held by the two groups. Results suggest that while astronomy teaching experience may increase the astronomy interest of elementary school teachers, this experience does not appear to affect their astronomy conceptions.

C2-6-2

PRESERVICE ELEMENTARY TEACHERS' BELIEFS ABOUT SCIENCE TEACHING AND LEARNING AND PERCEIVED SOURCES OF THEIR BELIEFS PRIOR TO THEIR FIRST FORMAL SCIENCE TEACHING EXPERIENCE

Sheila M. Jasalavich, Syracuse University

The purpose of this study was to: elicit beliefs about science teaching and learning held by preservice elementary teachers prior to teaching science and probe for the sources of their beliefs. 14 participants completed a structured reflection exercise, a sequencing instruction exercise, and an interview conducted using an Interview-About-Instances of Elementary Science Teaching task. Inductive analysis, triangulation of data sources, and matrix compilation of responses indicate that preservice elementary teachers' beliefs about science teaching and learning emphasize interpersonal/affective components of teaching. Cognitive/academic dimensions are limited. The complexity and uncertainty of teaching are poorly understood. Beliefs are often inconsistent. Beliefs are primarily based on prior personal learning experience. The influence of pedagogy courses on initial beliefs is minimal.

GENDER COMPARISONS: ATTITUDES OF PRESERVICE ELEMENTARY SCIENCE METHODS TEACHERS TOWARD SCIENCE AND SCIENCE TEACHING

C2-6-3

Betty L. Bitner, Southwest Missouri State University

The purpose of this causal-comparative study was to compare attitudes of male and female preservice elementary science methods teachers toward science and science teaching. The stratified random sample (N = 80) was drawn from the population of preservice elementary teachers enrolled in an elementary science methods during Fall 1990, Spring 1991, and Summer 1991. The sample was homogeneous in ACT and C-BASE test scores. The Science Attitude Scale for Preservice Elementary Teachers-Revised was administered to the population during the first week of classes. The independent t-tests for the total attitude scale, subscale for positive statements, and subscales for negative statements indicated no significant gender differences ($p < .01$). The rationale for no gender differences includes the homogeneity of the sample on ACT and C-BASE tests, the hands-on approach to learning stressed in the Teacher Education Program, and the constructivist process used in several courses designed for the elementary teacher.

C2-6-4

LEARNING TO TEACH ELEMENTARY SCIENCE: CHANGING IMAGES, METAPHORS, AND BELIEFS.

Sharon E. Nichols and Thomas M. Dana, Florida State University; Carol Briscoe, University of West Florida

This study of prospective elementary teachers and their sense making during a science "methods" course and associated field experiences provides insight into the value of adopting a constructivist approach to teacher education. Results indicate that one of the keys to making field experiences powerful is to begin with making prior knowledge of teaching and learning explicit in terms of images, metaphors, and beliefs. Furthermore, it was learned that structured field experiences with exemplary science teachers can provide prospective teachers with opportunities to construct alternative images of teaching and learning and to evaluate the viability of their prior knowledge about classroom life. By building on what research says about learning and viewing prospective teachers as learners of science teaching, we have found that field experiences, contrary to some previous research, can be a valuable component to a constructivist orientated teacher education program.

Contributed Papers: Teacher Attitudes/Beliefs
C2-7

C2-7-1

AN EXAMINATION OF PRESERVICE AND INSERVICE SECONDARY SCIENCE TEACHERS' BELIEFS ABOUT SCIENCE-TECHNOLOGY-SOCIETY

Peter A. Rubba and William L. Harkness, Penn State University

The purpose of the investigation was to examine and compare preservice and inservice secondary science teachers' beliefs about science-technology-society (STS), particularly the nature of science and technology, and their interactions within society. Data were collected using the Teachers' Beliefs About Science-Technology-Society, an "empirically developed multiple choice instrument" that contains 13 items on the nature of science, technology, and their interactions within society. Two samples of convenience were used in the study, one consisting of 26 preservice secondary science teachers enrolled in two sections of a secondary science teaching methods course at an eastern land grant university, and 19 inservice secondary science teachers enrolled in a science education workshop at a nearby but different university in the same state. The data were statistically analyzed to test three null hypotheses. The findings indicated that the preservice and inservice science teachers' understandings about science, technology and their interactions in society do not differ, for the most part. Both included misconceptions that have serious implications for science instruction and science teacher education, especially in relation to integrating STS into science.

C2-7-2

EXAMINING VALIDITY ISSUES WITH A SCIENCE TEACHING ATTITUDE SCALE.

Mark D. Guy, The University of Georgia

The purpose of this study was to address validity issues surrounding a science teaching attitude scale. Estimates of the reliability of a published attitude scale were compared with the original findings. The instrument's face validity was assessed from the perspective of preservice teachers rather than a panel of judges. Preservice teachers' reasons for responding to a particular item were also analyzed. Results indicated that the reliability of the instrument was reasonably well matched to the original findings on two of three subscales. The instrument's face validity was challenged for one-third of the items. Differing contextual frameworks were identified in individuals with identical item responses. Findings support complexities involved in valid attitude assessment.

C2-7-3

TEACHER EMPOWERMENT AND CURRICULUM REFORM IN SECONDARY SCIENCE AND MATHEMATICS CLASSES: A MODEL OF CHANGE.

Sheryl McGlamery and Sherry Nichols,
Florida State University

The study described was designed to investigate conditions encountered as teachers of secondary science and math attempted to reform curricula based on their personal beliefs and epistemologies. This interpretive study allows us to observe the cultural constraints an individual teacher encounters as he/she acts as a change agent of curricula within a school culture. The assertions presented in this research project address the following issues: (1) teachers perceptions of change opportunities; (2) strategies used by teachers to augment change; (3)social conflicts experienced by teachers ; and (4) the development of a model of the process of curriculum reform process.

Paper Set: Conceptual Change
C3-1

LEARNING ABOUT LIGHT AND SHADOWS: A TALE OF THREE CHILDREN C3-1-1

Elizabeth A. Wier, University of Delaware

A number of studies have shown that conceptual change strategies hold promise for facilitating children's construction of scientific concepts. However, it has also been documented that children exposed to the same lessons can vary widely in the progress they make in understanding targeted concepts. This paper examines the thinking and involvement in lessons of three third grade children as they progressed through a conceptual change unit to determine what helped or hindered them in successfully constructing scientific conceptions. The children selected for the study began at different levels of understanding of light and shadow concepts and their knowledge grew at different rates. To determine the causes for the difference in their progress the following were examined: the children's pre and post interview responses, videotapes of the lessons, and their teacher's perceptions of the children's abilities and manner of participation in the classroom. The study points out the importance of awareness of children's predispositions for science and for learning, in general, as well as an understanding of their preconceptions in making curricular decisions and implementing conceptual change lessons.

CONDITIONAL KNOWLEDGE IN AN EXPERIENCED TEACHER'S CONSTRUCTION AND IMPLEMENTATION OF A 3RD GRADE CONCEPTUAL CHANGE SCIENCE UNIT. C3-1-2

Julie Schmidt and Jean Leach, University of Delaware

Interviews and stimulated recalls of an experienced teacher's construction and implementation of a conceptual change model were analyzed for categories of conditional knowledge. Concerns over affective aspects of a conceptual change approach constituted the chief adaptation of the model. Preservation of student success, self-esteem, and positive attitudes served as the larger framework within which the teacher implemented the cognitive components of the model. Analysis of the data revealed shifts in the teacher's pedagogical categories influenced by the implementation of the model. Specifically, subtle yet significant changes in the teacher's methods included planning and assessing instruction around children's thinking, neutrality in responding to children's ideas, the use of probing questions, sharp reductions in review time, attention to the cognitive benefits of students' representations and constructions of explanatory models, and an increased latitude of the discursive arena. Analysis of classroom lessons indicated that the teacher adapted some features of a model more readily than others, suggesting both a logical order in the adoption of critical features and the contribution of pre-existing compatible teaching practices. The research offers recommendations for novices' gradual adoption of a conceptual change model.

C3-1-3

THE ROLE OF THEORY IN MAKING SENSE OF EVIDENCE AND ARGUMENTS IN PRIMARY SCIENCE CLASSROOMS

Nancy Brickhouse, University of Delaware

This study examined the teaching and learning in classroom science lessons in one second grade and two thrid grade classrooms. In particular, children's own theories about light and shadows, as revealed in their clinical interviews prior to instruction, were followed through two weeks of classroom instruction. The analysis of videotapes of classroom instruction found relationships between children's abilities to collect and make sense of data and whether or not their observations had been driven by some "big idea" about the nature of light. Children's abilities to remember and explain accurately particular tasks on the post-interview were also related to these constructions of "big ideas."

C3-1-4

THE CURRICULUM DEVELOPMENT LAB: A VEHICLE FOR STAFF DEVELOPMENT IN PRIMARY SCIENCE

Deborah C. Smith, University of Delaware

The paper describes the research-based rationale for, and design of, the Curriculum Development Lab, a school-based program of staff development in primary science. The program focuses on teachers' knowledge of children's ideas in science and their development of conceptual change teaching strategies, within a collegial community engaged in curriculum development. The Lab program is designed as a cognitive apprenticeship. Teachers observe, then take over, classroom science lessons in the Lab's demonstration classroom. Then, they return to their own classrooms, with coaching from Lab staff. The paper describes the various ways in which the program reduces demands on teachers, in order to scaffold their construction of new knowledge and teaching practices in their science teaching. It also provides examples of the ways in which opportunities for teachers to reflect on classroom teaching and learning events, both as individuals and as a group, are built in to the program.

Contributed Papers: Preservice/Inservice Education
C3-2

TEACHING EVOLUTION: THE INFLUENCE OF PEER INSTRUCTIONAL MODELLING

C3-2-1

Lawrence C. Scharmann, Kansas State University

The influence of an NSF-sponsored two-week institute upon secondary biology and earth science teachers regarding their understanding of and ability to apply the nature of science within instruction on evolutionary topics was investigated by the project director. Also investigated, was the influence upon 2nd year participants by seven peer or "mentor" teachers (from the previous year's institute), who assisted the project director with the planning, implementation, and overall conduct of the 2nd year institute. At the conclusion, 2nd year participants showed significant increases in their acceptance of evolutionary theory and applied understanding of the nature of science. In addition, a significant reduction in participants' self-reported anxieties regarding the teaching of evolution was achieved. Finally, a qualitative examination was performed to assess the degree to which mentor and participant teachers were willing to consider the adoption of more student-centered instructional approaches for teaching evolutionary theory and applied principles.

EVALUATING AN INSERVICE MODEL THAT IMPACTS SCIENCE CLASSROOM PRACTICE

C3-2-2

David P. Butts, W. Anderson, M. Atwater, T. Koballa, P. Simmons, The University of Georgia and R. Hairston, University of Southern Mississippi

The purpose of this study was to design a conceptual framework for inservice programs and evaluate its impact on science teacher classroom practice. Based on the Koballa model of reasoned behavior, the three phases of the inservice program, awareness, arousal and action, were designed to influence both the internal and external beliefs of teachers. The 38 seventh grade teachers participated in a two year study. Pre and post program evaluations were used to itentify evidence of impact. Results indicated that changing what a teacher would like to do contributes less to their classroom practices than their beliefs about what the school expects them to do.

PRESIDENTIAL AWARDEES AS INSTRUCTIONAL MENTORS FOR MIDDLE LEVEL SCIENCE TEACHERS: A SUMMER INSTITUTE AND BEYOND. C3-2-3

Thomas J. Greenbowe, Iowa State University.
Cheryl L. Mason, San Diego State University
Barbara W. Saigo, Southeastern Louisiana University

This two year study sought to overcome the belief that summer institutes often fail to have long term effects on science teaching. The investigators and specially selected Presidential Awardees (PA's), classroom teachers themselves, developed and implemented a summer institute program with followup support during the academic year. The PA's determined the curriculum, provided the majority of the instruction and served as mentors throughout the program. By incorporating participant-oriented activities, the institute faculty communicated to the teachers that this was not intended to be a process-product experience but rather a reflective and interactive involvement. The results of pretest, posttest, and post posttest surveys and observations indicated that there was a significant change in the various areas tested.

TEACHER AND RESEARCHER DEVELOPMENT IN A PROFESSIONAL DEVELOPMENT SCHOOL: LEARNING ABOUT SCIENCE TEACHING FROM MULTIPLE PERSPECTIVES C3-2-4

Kathleen J. Roth, Jan Derksen, Corinna Hasbach, Constanza Hazelwood, Kathleen Peasley, Elaine Oren, Cheryl Rosaen, Priscilla Woodhams, Michigan State University
Elaine Hoekwater, Carol Ligett, Barbara Lindquist, Elliott Elementary School, Holt, MI

In a professional development school, these educators worked collaboratively in the Literacy in Science and Social Studies Project. Each participant took on a teacher-researcher role to explore teaching for understanding in science, social studies, and writing. Across a 2-year period participants studied both their own growth and development and their students' learning. The paper describes how this restructured work context and the teacher-researcher role influenced participants' understanding and practice of science teaching. Data collected across the 2-year period includes fieldnotes and audiotapes of weekly study groups, interviews with each participant, journal writing, and documentation of classroom teaching (fieldnotes, videotapes, interviews with students, etc.). Analysis focused on: a) insights about science teaching that emerged for each participant, and b) key features of the restructured context that supported professional growth. The teacher-researcher role enabled deep understandings of science teaching and learning to develop.

Symposium: Science Reform Project
C3-3

THE REALITY OF A SCIENCE REFORM PROJECT: STRUCTURE, DESIGN AND PRELIMINARY FINDINGS

Linda W. Crow, Baylor College of Medicine
and Ronald J. Bonnstetter, University of Nebraska

This symposium will provide an examination of a science education reform project in action. This reform, Scope Sequence, and Coordination of Secondary School Science (SS&C) has been proposed by the National Science Teachers Association. The Houston Project is one of five SS&C centers and has been in existence for a longer period of time. To examine the project thoroughly, the symposium will be divided into three parts. The first part will provide a description of the structure of the Scope, Sequence and Coordination (SS&C) project in Houston, Texas. The description will provide an overview of the process used to initiate this reform along with the individual methods used. The second part will describe the design of the ongoing evaluation of the project. Procedures, activities and uses of data will be carefully discussed. The third part of the symposium will provide the preliminary findings from the first year of field testing. These findings include results from data concerning students, parents, administrators and teachers. Gender and cultural characteristics will also be included. Results indicate that a successful field testing has occurred. Using these first year results, it will be shown how the second year of the project has been planned.

Contributed Papers: Problem Solving/Teacher Education
C3-4

C3-4-1

A QUALITATIVE AND QUANTITATIVE ANALYSIS OF EXPERT AND NOVICE EARTH AND SPACE SCIENCE TEACHER'S DECLARATIVE, PROCEDURAL, AND STRUCTURAL KNOWLEDGE

Robertta H. Barba, San Diego State University

The purpose of this study expert and novice earth and space science teachers by the declarative, procedural, and structural knowledge that they used while engaged in solving "typical" earth science tasks. A comparison of 6 expert and 6 novice earth and space science teachers revealed that expert teachers brought more declarative knowledge to the task, used fewer steps, generated more subroutines, generated more alternative solutions, moved less between declarative and procedural knowledge and solved problems more accurately than did novice teachers. The findings of this study support Norman's theory that experts perform with smoothness, automaticity, and less mental effort than do novices. Additionally, the findings have implications for the training of preservice earth and space science teachers.

C3-4-2

CRITICAL FEATURES OF AN ADVANCED EARTH SCIENCE SEMINAR SERIES FOR MIDDLE SCHOOL TEACHERS: AN EVALUATION

Joseph M. Ryan, Laurie Martin, and John Carpenter, University of South Carolina

A seminar series with seven presentations by earth scientists was examined as an approach to providing on-going education to a group of middle school science teachers. Objectives of the program were to improve teachers' knowledge of current research, their understanding of the researchers' contributions, motivation, and research methods, and to help the teachers to see the relevance of research to classroom teaching. The program was evaluated in progress and for a year following the completion of the program using both quantitative and qualitative data collection procedures. Various data sources provide a consistent picture of the program's strengths and weaknesses. Cognitive and affective objectives were substantially achieved. Recommendations for improving the program and for using of similar formats are described.

THE EFFECTS OF REPEATED INTENSIVE INSTRUCTION IN CUE ATTENDANCE UPON CUE ATTENDANCE BEHAVIOR AND INTERACTIVE THOUGHTS OF ELEMENTARY SCIENCE METHODS STUDENTS

C3-4-3

Ronald P. Hughes, California State University, Bakersfield, and Emmett L. Wright, Kansas State University

This study was conducted in order to discover the effects of three repeated cue attendance intensive instructions upon cue attendance behavior and interactive thoughts of elementary science methods students. Two areas of interactive thoughts were investigated: cue attendance prerequisite cognitive skills and lesson presentations. Data were collected utilizing the stimulus-response method with 21 preservice teachers. Analysis was completed by using repeated measures analysis of variance techniques comparing mean scores between the experimental and control groups. There were significant differences in the number of object and condition details reported by the experimental group as compared to details reported by the control group; the experimental group scoring higher values on the posttests than did the control group. There were significant interactions for group by repeated (A X B) at series 2 and 3 for event cues, series 3 object cues, series 3 condition cues, and series 1 property cues; again, the experimental group scoring higher values on the posttests than did the control group. The experimental group cue attendance skills became more enhanced than did the skills of the control group with repeated treatments. There were no significant main effects or group by repeated (A X B) interactions for cue attendance or lesson interactive thought processes.

C3-4-4

Influencing Teacher Thinking and Teacher Behavior Through Analysis, Feedback and Reflection

Teresa M. Kokoski, University of New Mexico

The purpose of this study was to examine the effects of analysis, feedback and reflection on the behavior and thinking of preservice teachers. Working with four preservice teachers assigned to middle and high school field experiences, the study revolved around an intensive supervisory experience which required an active participatory role for the preservice teachers. The guided analyses, centering on teaching strategies, served a dual role: (1) as a component of the intervention process; and, (2) as a means for data collection. Interviews, observations and structured writing tasks provided data on teachers' thought processes associated with the use of teaching strategies and professional development. The findings reveal that, behaviorally, over time the preservice teachers increased their use of lower level questions in their lessons, became more student centered in their teaching styles and improved the quality of their teaching. In terms of their thinking about teaching strategies, the data indicate shifts in thinking from descriptive to analytical. By the end of the supervisory experience, the preservice teachers: (1) began to associate the level of questions with the ability level of the students; (2) were able to discern differences in teacher-centered and student-centered lessons and discuss their reasons for doing lessons from varying modes; (3) measured their success as teachers by student achievement; and (4) reflected changes in attitudes about teaching relative to their field experience.

Contributed Papers: Chemistry Education
C3-5

C3-5-1

BELIEF AND ATTITUDE DIFFERENCES OF PREREGISTERED AND NONPREREGISTERED HISPANIC STUDENTS RELATIVE TO ENROLLMENT IN HIGH SCHOOL CHEMISTRY.

Carolyn B. Black and Frank E. Crawley, University of Texas at Austin

This study uses a contrasting groups design to examine the differences in personal, social, and control beliefs of ninth and tenth grade Hispanic students forming 2 groups: students who preregistered for chemistry for the following fall and those who did not. Employing the Theory of Planned Behavior, students were surveyed for beliefs, attitudes, and intentions toward enrolling in chemistry. Data collected from sampled classes (N=330) in two predominantly Hispanic (95%+) high schools revealed that only 18% of the students preregistered to take chemistry. Data from preregistered (N=58) and nonpreregistered (N=272) students were analyzed by regression analyses and theory trimming techniques. Results indicated that the intention of preregistered students was influenced only by their personal beliefs, which were: reaching career goals and learning more. Nonpreregistered students' personal beliefs were: reaching educational goals, learning more, having a good experience and succeeding with personal advancement; clearly indicated was the belief that taking chemistry would not aid their career goal. Nonpreregistrants perceived their parents, friends, and science teachers to be influential in their decision-making; they also believed that having good study skills and knowing more about chemistry beforehand controlled their enrollment intention.

C3-5-2

STOICHIOMETRIC PROBLEM SOLVING IN HIGH SCHOOL CHEMISTRY.

Hans-Jürgen Schmidt, University of Dortmund

The purpose of this descriptive study was to develop and to test questions on stoichiometric calculations that allow quick mental calculations and to identify students' problem-solving strategies. Subjects were 7,441 german senior high school students who completed paper and pencil tests. Additionally, discussions with the students about how they solved the test items were videotaped.
From students' written comments and the discussions resulted that most of the students applied a problem-solving strategy that is not described in schoolbooks. The result suggests to use these particular test items and problem-solving strategies to introduce students to stoichiometric calculations.

FROM "ALGORITHMIC MODE" TO "CONCEPTUAL GESTALT" IN UNDERSTANDING THE BEHAVIOR OF GASES: AN EPISTEMOLOGICAL PERSPECTIVE.

C3-5-3

Mansoor Niaz, Universidad de Oriente and William R. Robinson, Purdue University.

According to Hanson a law might have been arrived at empirically (enumerating particulars), it could then be built into a hypothetico-deductive (H-D) system as a higher order proposition. From an epistemological perspective, resolution of gas problems based on the Ideal Gas Law, derived by the inductive process (Boyle, Charles, Gay-Lussac), primarily requires manipulation (enumeration of particulars) of the different variables, and thus can be characterized by the "algorithmic mode". Resolution of gas problems based on the Kinetic-Molecular theory of Maxwell and Boltzmann (H-D system) requires the understanding of a pattern within which data appear intelligible,i.e., a sort of "conceptual gestalt". The main objective of this study is to compare performance of students on gas problems that require two distinct approaches: "algorithmic mode" and "conceptual gestalt". Results obtained show that performance on problems requiring the two approaches is quite different. Conclusion: One should not expect training or experience with algorithmic problems to develop the understanding required to solve conceptual problems.

C3-5-4

A QUALITATIVE STUDY OF THE EFFECTS OF STS ISSUES ON HIGH SCHOOL CHEMISTRY STUDENTS.

Jon E. Pedersen, University of Arkansas

A model for the teaching of Science-Technology-Society (STS) issues was presented to ninety-six high school Chem-Comm. chemistry students (11th and 12th graders), who were assigned to the study as in-tact classes. In the classes students were divided into small groups of four, and each group of four was separated into two halves representing the pro and con sides. Students were asked to research, discuss and prepare for a class debate in which pro and con groups worked together. After the debate the original groups of four returned to discuss the issues, reach consensus, and write a group report.
Observations were made in the class as well as interviews taken with the students. Twenty students were selected and interviewed about their experiences in the current science course. The results of the interviews and observations indicate that STS issues effected the way in which students view science. Students were more positive about science, the science class, chemistry, and the effect that science had on them and society. Students also indicated a willingness to get involved in and actively participate in social issues as they effected the community in which they lived.

Contributed Papers: Teaching Strategies
C3-6

EVERYTHING DEPENDS ON THE TEACHER: MULTIPLE PERSPECTIVES ON CLASSROOM CONTROL AS A CONSTRAINT TO EFFECTIVE CHANGE IN SCIENCE TEACHING — C3-6-1

Carol Briscoe, University of West Florida

This paper presents interpretations from a collaborative case study with a chemistry teacher who was committed to changing his practices to facilitate problem solving in science through cooperative learning activities. The emphasis of this study is on how the teacher made sense of management and control in his classroom as he attempted to restructure the learning environment to be less teacher centered than it had been in the past. The study explicates how school culture, classroom social structure, and personal cognitions (i.e. beliefs, images) facilitated or constrained the teacher's attempt to construct coherence in his pedagogical knowledge regarding management and discipline and his practical knowledge about teachers' and students' roles and responsibilities in cooperative learning settings in science. Implications of the study are that staff development programs created to assist teacher in changing the manner in which science curriculum is implemented ought to consider the salience of social and cultural contexts in influencing teachers' beliefs and actions.

COMPARING ALGORITHMIC AND HEURISTIC INSTRUCTIONAL APPROACHES IN TEACHING PROBLEM SOLVING IN HIGH SCHOOL CHEMISTRY. — C3-6-2

Obed Norman, Lawrence Hall of Science, University of California at Berkeley

The purpose of this study was to compare the impact of instructional approaches on the performance of high school chemistry students on a problem solving test on chemical equilibrium. Four teachers and 183 students participated in the study. Each teacher instructed one class using an algorithmic approach and another using a heuristic approach that focussed more on the conceptual relationships. The students in the two treatment groups were cognitively comparable as their mean scores on three cognitive tests did not differ significantly. The students instructed with algorithms did however outperform the heuristic group at a statistically significant level. The findings of the study are discussed in the light of the divergent research approaches of expert-novice studies on the one hand and idea analysis studies on the other. Idea analysis - a research perspective used in mathematics education - advocates the use of instructional approaches that are compatible with students' conceptualizations. An important insight that has emerged from idea analysis is that approaches that may be productive for mature understandings may be counterproductive with immature conceptualizations.

STUDENTS' UNDERSTANDING IN ELEMENTARY THERMODYNAMICS: A COMPARISON OF TWO TEACHING APPROACHES

C3-6-3

Sofia Kesidou, University of Pittsburgh

In this paper the results of two studies on students' conceptions in the areas of elementary thermodynamics and energy are compared. The first study concerned thirty-four interviews with grade 10 students (aged between 15 and 16) in a German High-School who, during lower secondary level, had been taught elementary thermodynamics and energy within a traditional approach. The second study concerned ten interviews with grade 11 students who, during lower secondary level, had served as an experimental group for a newly developed, non-traditional approach to elementary thermodynamics and energy. We find the second group developed energy conceptions which contain some essential characteristics of the physicist's energy concept, whereas the first group's energy concepts are based on everyday frameworks. In addition, the second group developed a framework in elementary thermodynamics which is more similar to the physicist's than the framework the first group developed. For example, whereas a considerable proportion of students in the first group viewed heat as an intensive quantity, students in the second group viewed heat as something transferred from one body to another because of a temperature difference between the two bodies. However, in both groups students did not view heat as a separate concept from temperature.

C3-6-4

PHYSICS PROBLEM SOLVING AND ITS SOCIAL CONTEXT IN SECONDARY SCHOOL.

Armando Contreras, Universidad de Los Andes, Trujillo, Venezuela.

The aim of this descriptive research study is to interpret the nature of problem solving events as they occur in the context of social interactions between teachers and students. The study is based on a 3 year-long ethnographic research conducted with 10 physics teachers in the venezuelan Andes. More than 120 observations were conducted alongside with formal and informal interviews with teachers and students, document gathering and videotaping of selected lessons. The teachers and students observed relied on an alienating and overwhelming usage of numerical physics problems, in which the "formula" was the key element during the actual solving process. The study raises some concerns about the contemporary cognitivist approaches on problem solving, the training of physics teachers to handle complex social situations, and student learning of physics laws and principles.

Contributed Papers: Gender Differences
C3-7

C3-7-1

SCHOOL EFFECTIVENESS AND SCIENCE ACHIEVEMENT: ARE THERE ANY SEX DIFFERENCES?

Deidra J. Young and Barry J. Fraser, Curtin University

The purpose of this study was to use secondary analysis of a database known as the Second International Science Study to examine the role of student, school and home factors in explaining student differences in science achievement and attitudes, especially sex differences in achievement and attitudes. This study employed methods of analysis which accommodated both the complex sample design and the multilevel nature of the data. As expected, sex differences were found to be greatest in physics achievement and school enjoyment. The home background of the student was found to be related to achievement in science differently for boys and girls. Student characteristics found to explain student differences best in this study were the student's socio-educational level (home background), the student's attitude towards science (importance of science for 10-year-old students and goodness of science for 14-year-old students), the student's verbal and mathematical abilities and the sex of the student. School effects were then investigated and the three school level variables were found to explain student differences in achievement best were the average verbal and mathematical abilities of students attending the school and the average home background of students attending the school.

C3-7-2

CONSTRUCTIVISM AND GENDER-INCLUSIVENSS: HAS ASSESSMENT KEPT PACE?

Lesley H Parker and Léonie J Rennie, Curtin University of Technology

The purpose of this paper is to draw together two themes presently discernible in science education, constructivism and gender-inclusive science, and to point out that the successful implementation of both in science education may be dependent upon concomitant changes in the assessment of students' learning. Constructivism and gender inclusive science are changing the nature of science learning strategies believed to be associated with effective science education. Both are increasing the emphasis placed on student participation, especially through cooperative group learning and increased language and communication skills. In both, the development of assessment strategies which are authentic in terms of the objectives, content and teaching strategies has lagged behind. There are clear indications that assessment will need to shift in the direction of a much stronger focus on the process rather than the product of learning, and that the reward system associated with assessment will need to acknowledge much more the legitimacy of personal and social constructs of students.

Sex differences on the Maine Educational Assessment Science Test. **C3-7-3**

Kate Scantlebury and Scott F. Marion, University of Maine

The study was designed to examine the purported "gender gap" on science portion of the Maine Educational Assessment [MEA] test. This test was administered to all Maine public school fourth, eighth, and eleventh grade students. Twelve forms, each containing 16 questions, were administered in 1989 with each student responding to one form. Items were designed to assess achievement in four content areas (scientific inquiry, life, earth/space , and physical sciences) and two process levels (knowledge/comprehension and application/higher order). For the 1989 test, analyses were conducted on the standardized scores eighth (n = 14,644), and eleventh (n = 13,908) grades. Mean scores were calculated for each student in the content areas and process levels. In both Grade 8 and Grade 11 girls scored lower than boys on content items relating to the physical sciences and the earth/space sciences, and there were almost no differences on the life science or scientific inquiry questions. All effect sizes computed for Grade 11 were significant and larger than those at Grade 8 level. This may be attributable to different patterns in science course selection by male and female students or different out- of- school science experiences for girls compared with boys.

C3-7-4

Sex differences in the processes influencing science course-taking patterns of college undergraduates.

Scott F. Marion &Theodore Coladarci, University of Maine

This study was designed to investigate the direct and indirect influences of sex and several intervening variables on college course selection in the quantitative sciences. The path model developed for this study explained 34% of the variance in the dependent measure--substantially more than previous research with the same data set. The analyses yielded three major findings: (a) after statistically controlling for all of the other independent variables in the model, being female still had a statistically significant negative impact on choosing quantitative science courses, (b) high school science and math courses appears to be the most important mediating variable in the model because of its direct effect on the dependent measure and its indirect influence on achievement and intended field of study, and (c) the differences in the explanatory ability of the model for males and females, as well as the variation of the importance several key paths indicates that other gender-related variables may be impacting the model. The conclusions explore how two of these factors: the hidden curriculum and the genderization of science may impact the process of college science course selection posited in this study.

Symposium: Teacher Enhancement Projects
C5-1

MIXING PARADIGMS IN EVALUATING TEACHER ENHANCEMENT PROJECTS.

James D. Ellis, BSCS; Paul J. Kuerbis, The Colorado College; Larry G. Enochs, Kansas State University; and Philip G. Goulding, BSCS

This symposium will open for discussion the question of using approaches from both the quantitative research tradition and the interpretive research tradition. The presider will introduce the symposium with a brief overview of *ENLIST Micros III* – a BSCS teacher enhancement project to establish a national network of regional teacher centers to help science teachers improve their use of advanced educational technology. The panel members will begin by reporting on four research projects that were conducted as different approaches to evaluating the effectiveness of *ENLIST Micros III*. Two of the studies followed the quantitative tradition by using paper-pencil assessment instruments to gather data on outcomes from students and teachers. Two studies used interpretive research approaches. One gathered data directly from participating teachers through intensive field observations and interviews. The other used data from implementation plans and portfolios prepared by the staff from each center and from site visits to each center. Once the panel members have presented their studies, the audience will discuss issues associated with mixing findings from two different research paradigms.

Symposium: Cooperative Inquiry
C5-2

DOING CO-OPERATIVE INQUIRY: THE CHALLENGE OF UNDERTAKING A NEW RESEARCH METHODOLOGY

Karen Sullenger, University of New Brunswick; Mark Holland, Department of Education, Province of New Brunswick; Mariona Espinet, Universitat Autonoma des Barcelona; Bill Kyle; Purdue University; Ken Tobin and Karl Hook, Florida State University

The need for curriculum reform in science education, the admitted failure of science education research to produce the needed reform, and the paradigm shift within the science education research community towards a constructivist philosophy underlie many science education researchers' search for new methodologies. As a result, co-operative inquiry has gained increasing support among science educators as a research strategy. Co-operative inquiry, is an umbrella term which refers to research which seeks to study with and for rather than on people. We would argue that co-operative inquiry as a research approach is in the position that qualitative research found itself five to ten years ago -- having to prove it worth and validity. This symposium seeks to explore through open discussion the challenges associated with co-operative inquiry. The participants are also interested in considering such issues as: the process of integrating theories about knowing, research, and method, as well as, putting the resulting research strategies into practice (Does co-operative inquiry as a research strategy meet our research needs?); the benefits and possible establishment of a co-operative inquiry networking system; and the NARST community's role in promoting change when new methodologies are undertaken.

Symposium: Assimilation Theory
C5-3

THE CURRENT STATUS OF AUSUBEL'S ASSIMILATION THEORY IN SCIENCE EDUCATION.

Symposium Presider:
Professor James Shymansky, University of Iowa
Presenters:
Professor Joseph D. Novak, Cornell University
Professor Patricia Simmons, University of Georgia
Professor Ann Cavallo, University of Oklahoma
Professor Fermin Gonzales, Univ. Publica De Navarra

We will review the current status of David Ausubel's assimilation theory of learning, including changes or additions to the theory since it was first put forward in 1962. Relationships to constructivist learning psychology and epistemology will be discussed. Research based on assimilation theory will be presented. Reports will include discussion of the interplay between epistemological views and learning, expert-novice studies, race and gender issues, and applications of assimilation theory in school settings, including current work under way in Spain. The presentations will highlight theoretical issues pertinent to the research studies presented, and indicate implication of research finds for assimilation theory. Relevant implications for other theoretical views will also be discussed. Discussion of questions from the audience should help to define and clarify the current status of assimilation theory and its value for guiding research and practice in science education.

Contributed Papers: Development of Reasoning
C5-4

C5-4-1

THE EFFECTS OF ADDING A PREDICTION/DISCUSSION PHASE TO A SCIENCE LEARNING CYCLE

Derrick R. Lavoie, Montana State University, Bozeman, MT 59717

This purpose of this study was to compare prediction/discussion-based learning-cycle (PDLC) instruction with traditional learning-cycle (LC) instruction. While PDLC and LC treatments taught identical learning-cycle lessons, the PDLC treatment initially administered prediction-problem sheets followed by whole-class and small-group discussion. Five teacher/researchers each taught one PDLC and one LC biology class (total sample size =300 students), for one semester. Qualitative data involved interpretive observations, collected daily by teacher/researchers and field observers, and a final questionnaire. Quantitative data involved pre and post-test data that assessed students' logical-thinking abilities, science process-skill abilities, and conceptual understanding. Compared to traditional LC instruction, PDLC instruction resulted in greater student motivation to carry out scientific investigations; more positive student attitudes toward science, the learning cycle, and their peers; and greater inter-peer interactions during traditional phases of the learning cycle. Significantly greater gains in conceptual understanding, logical thinking abilities, and process skill achievement were evident with the PDLC treatment. Prediction sheets revealed substantial information regarding students' prior knowledge and alternative scientific conceptions. Several suggestions are made for the developing, teaching, and evaluating prediction/discussion-based learning-cycle instruction.

C5-4-2

THE DEVELOPMENT OF ELEMENTARY SCHOOL STUDENTS' IDEAS RELATED TO THE CATEGORIZATION OF LIVING THINGS

Barbara G. Ladewski and Joseph S. Krajcik, University of Michigan
Jane S. Levy and Rick Hall, Ann Arbor, Michigan

We used qualitative methods to explore elementary school-age children's conceptions about a basic biological concept (What does it mean to say something is "alive"?) and examined how such conceptions vary with chronological age. The study also examined how young children's prior conceptions are affected by instruction that directly confronts those conceptions and how young children's conceptions of science process develop. Elementary school children were interviewed both before and after instruction that was designed to address specific prior conceptions. Results indicated that prior science conceptions of elementary school-age children tend to be related to the chronological age of the child, that young children are often comfortable with contradictions in their conceptual framework, and that young children possess important prior conceptions about science process as well as about science content.

A NEW VIEW OF STAGE THEORY

Anton E. Lawson, Arizona State University

C5-4-3

Piaget has characterized intellectual development in terms of four stages in which the latter stages are marked by the acquisition of novel thinking patterns (operations). The purpose of this paper is to propose an alternative stage theory in which the pattern of reasoning basic to intellectual functioning does not change from stage to stage as Piaget claims. Rather the basic pattern remains the same but the context to which that pattern can be applied changes. The first stage (birth to 18 months) is nonverbal yet the child is able to reason in the if...and...then... hypothetico-deductive (HD) form provided reasoning is initiated with a direct observation. The second stage (18 months to 6 years) differs in that the nonverbal HD reasoning can be initiated with non observed events. HD reasoning in the third stage (6-7 years to early adolescence) is verbally mediated but must be initiated with observed events. The HD reasoning of stage four (early adolescence and older) can be initiated by hypothetical (imagined) events. In this sense it is the only stage in which reasoning is "scientific". Implications for science instruction will be discussed.

CONCEPTUAL AND REASONING PATTERNS ON MOTION TASKS AMONG MALAYSIAN STUDENTS AND ACROSS PIAGETIAN COGNITIVE REASONING LEVELS

C5-4-4

Kueh Chin Yap, University Technology of Malaysia

While numerous studies on alternative conceptions and reasoning have been carried out in developed countries, there is a lack of such studies in developing countries. There are also few previous attempts to link the constructivist model with the Piagetian theory. This study is an attempt to bridge the gaps mentioned. The sample comprised of secondary and university students in Malaysia. Results indicated that there were similarities and differences in conceptual and reasoning patterns on motion tasks across cultures. There were also differences across Piagetian cognitive reasoning levels. Formal students were observed to attempt the usage of patterns based on physical aspects of the tasks. Such findings are basically consistent and similar to previous findings of surface and deep processing related to learning and problem solving.

Contributed Papers: Science Attitudes
C5-5

C5-5-1

COGNITIVE DISSONANCE THEORY: A STRATEGY FOR IMPROVING MIDDLE SCHOOL SCIENCE ATTITUDES.

Frank L. Misiti, Bloomsburg University, Bloomsburg, PA

Based on the tenets of Festinger's theory of cognitive dissonance, five preconditions for dissonance arousal were operationalized in a counterattitudinal essay. The preconditions were: irrevocable commitment, perceived choice, minimum incentive, personal responsibility for consequences, and foreseeability of negative consequences of behavior. The sample was 141 middle school students. Subjects were asked to write essays on the theme "Why I like learning science," with the expectation that the essays would be displayed and read by their peers. It was predicted that dissonance arousal following the writing task would be reduced by a positive attitude change in the direction of the counterattitudinal advocacy. A 3x2x3 ANCOVA assessed the effect of grade level, gender, and three treatment levels on attitude change; a pretest was treated as the covariate. A significant three-way interaction of grade level, gender, and treatment level on science attitude scores was found.

C5-5-2

VARIABLES WHICH AFFECT YOUNG WOMEN'S SCIENCE ACHIEVEMENT AND ATTITUDES TOWARD SCIENCE

Charles R. Warren, The Onio State University

Previous studies have attempted to document the effects of variables which affect science attitudes, and achievement in science. These studies have not been successful in explaining much of the variance in science achievement, or attitudes. This study attempted to synthesize previous efforts into a unified model of those variables and to test the model at the secondary level. This composite model featured a separation between the in-school and out-of-school variables which affect students because of the potential usefulness to schools. A two-phase design which included a questionnaire (n=1123) and interviews (n=110) was used. Students in grades 6, 8, 9, 10, 11 and 12 in two school districts in the midwest United States (one urban and one suburban) participated. Longitudinal and crossectional methods were used in the analysis. Predictive models of achievement and attitudes were constructed from the data and were able to explain more than 40 per cent of the variance in science attitudes and achievement at the 6th,, 8th, 10th and 12 grade levels. Findings included: 1) There were more variation in attitudes and achievement within the sexes of students than between them; 2) the most significant predictor of science achievement was students' attitude about their ability to perform in science class; 3) the most significant predictor of science attitudes was students' enjoyment of science class; 4) science attitudes and achievement declined for students as they progressed through secondary school and recovered only partly by the end of their secondary school experience; and 5) the decline in science attitudes was greater than for science achievement.

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C5-5-3

STRUCTURAL EQUATION MODELING OF SCIENCE AND MATHEMATICS ACHIEVEMENTS OF TENTH-GRADE FEMALES IN ARAB JERUSALEM: AN APPLICATION OF THE THEORY OF PLANNED BEHAVIOR

Sophia Arditzoglou and Frank Crawley, The University of Texas at Austin

The study aimed to identify the determinants that influence science and mathematics achievements of tenth-grade Palestinian females enrolled in the private schools of Arab Jerusalem using the Theory of Planned Behavior (TPB) as the theoretical framework. Of the 271 participants, 90, 90 and 91 students responded to the Mathematics, Life Science, and General Science Questionnaires, respectively. Simple correlation analyses revealed that previous achievement and anticipated scores are correlated to mathematics and science achievements, career goals are correlated to mathematics and life science achievements, mother's educational level is correlated to mathematics achievement, and father's educational level is correlated to life science achievement. LInear Structural RELations (LISREL) analyses of ten structural models also showed that: (1) the addition of a path from previous behavior to future behavior to the TPB model is applicable to the prediction of achievement intention; (2) achievement intention does not directly influence achievement; (3) previous achievement directly influences future achievement; (4) both attitude and perceived behavioral control, but not subjective norm, influence achievement intention.

Contributed Papers: Environmental Education
C5-6

THE OUTCOMES OF A SUMMER INSTITUTE IN ENVIRONMENTAL EDUCATION FOR ELEMENTARY TEACHERS FROM FOUR STATES. C5-6-1

Katherine I. Norman, The University of Kansas

During the 1991 Summer Institute in Environmental Education, teachers created instructional modules containing background environmental and ecological information, two environmental investigations designed around the learning cycle, pre/post-tests, integration strategies, adaptation ideas, extension activities, and alternative assessment methods. The teachers also developed their own follow-up plans to the institute to aid them in improving their teaching of environmental education. This paper reports on the field tests and teachers' evaluations of the instructional modules, the implementation of teachers' follow-up plans, and a fall retreat for participating teachers planned and implemented by the teachers. This project was funded by a grant from The Environmental Protection Agency, Region VII.

A COMPARISON OF EARLY ADOLESCENTS ENVIRONMENTAL CONTENT, BELIEF AND AFFECTIVE STRUCTURES WITH THEIR GENERATION OF SOLUTIONS TO ENVIRONMENTAL PROBLEMS C5-6-2

Ann M. Novak, Ann Arbor, MI

Utilizing a cognitive psychology framework, I compare the content, belief, and affective structures that early adolescents possess for certain environmental issues with their relationship in generating solutions to environmental problems. A model of learning and problem solving is introduced that represents an individual's overall conceptual framework as consisting of content, belief and affective structures.

Using clinical interview techniques, students responded to an unstructured problem and two problematic vignettes in which problems were implied rather then explicitly stated. Analysis was based on categorizing statements as either content, belief, or affective (emotional) statements. The problem vignettes were analyzed for problem identification and all three problems were analyzed for percent of content, belief and affective statements.

This study had several findings. A key component in the way individuals identify and solve environmental problems that are not explicitly stated is the integration or lack of integration of their content knowledge, beliefs and affect. It appears that when "given" an unstructured problem, as might happen in a science classroom, individuals turn on their "science knowledge," relying on content. However, when asked to put themselves in real life situations, they rely less on content and more on beliefs and affect.

C5-6-3

EFFECTS OF ISSUE INVESTIGATION AND ACTION TRAINING ON CHARACTERISTICS ASSOCIATED WITH ENVIRONMENTAL BEHAVIOR IN JUNIOR HIGH STUDENTS.

John Ramsey, University of Houston

The purpose of this study was to assess the instructional outcomes of a methodology designed to enhance the responsible environmental behavior of middle school science students. Four groups of eighth and four groups of seventh grade students received a one-semester experimental treatment; similar groups received control treatment. Phenomenological and Likert scale instruments were used to collect data concerning subjects' environmental behavior, locus of control, behavioral self-efficacy, environmental sensitivity, and knowledge of environmental action strategies. Pre and post scores were analyzed for any significant change. The results indicated significant gains in responsible environmental behavior and in most of the associated variables for both seventh and eighth grade groups. The findings supported the aims of the methodology.

C5-6-4

Constructivism in Outdoor Based Science: A Case Study of the Teton Science School.

Michael T. Hayes, University of Utah

The purpose of this study was to investigate the use of constructivism in the outdoor based science programs of the Teton Science School. Three groups ofseventh and eighth grade students were observed over a ten day period. Constructivism was used as the theoretical base to guide observations. Constructivism was not used as much as originally hypothesized.

Contributed Papers: Attitudes/Preferences
C5-7

C5-7-1

TEACHING STRATEGIES IN SCIENCE THAT ADDRESS THE LEARNING PREFERENCES OF MALE AND FEMALE MIDDLE LEVEL STUDENTS

M. Gail Shroyer, Kansas State University; Janet Carlson Powell and Kathy Backe, BSCS.

The work presented in this paper is one part of ongoing research associated with a middle school curriculum development project funded by NSF. The study was conducted to gain a better understanding of adolescent girls' and boys' interest in science in order to develop a curriculum that meets the needs of all students. We interviewed 72 students in grades 6 - 8 to learn more about their learning preferences for activities, materials, and resources within the science curriculum. Overall boys and girls demonstrated similar preferences for science activities, materials and resources with only a few noted exceptions. They shared a preference for a wide variety of activity-oriented strategies. Most importantly, males and females were particularly interested in activities and resources that are not commonly found in middle school science classes. Both genders favored laboratory activities, experiments, field trips, videos, films, guest speakers, and the use of video recorders. Both genders were more likely to mention a disinterest in textbooks, worksheets, and workbooks. A major implication of this study is that a dynamic activity-oriented curriculum that incorporates a variety of strategies, resources and materials should enhance both male and female interest in science.

C5-7-2

AN INVESTIGATION OF THE EFFECT OF A SCIENTIFIC RESEARCH EXPERIENCE ON TEACHERS' ATTITUDES TOWARD INQUIRY-BASED INSTRUCTION.

Douglas Huffman, University of Minnesota

The purpose of this study was to investigate the effect of a scientific research experience on elementary and secondary science and social studies teachers' attitudes toward inquiry-based instruction. The Research Exploration for Teachers program (REX) at the University of Minnesota teamed 32 teachers with 16 faculty members in order to give the teachers a unique opportunity to actively engage in scientific research as a means of improving science instruction. Teachers' attitudes toward inquiry-based instruction were measured before and after the research experience with a 30 item Likert Scale instrument that was designed by the author. Results indicate that the teachers not only began the research experience with relatively positive attitudes toward inquiry-based instruction, but also reported significantly more positive attitudes toward inquiry-based instruction on several items after participating in the research project.

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C5-7-3

AFFECTIVE CHARACTERISTICS OF URBAN AFRICA AMERICAN AMERICAN MIDDLE SCHOOL STUDNETS WITH HIGHLY POSITIVE ATTITUDES TOWARD SCIENCE.

Catherine Gardner, Mary M. Atwater, and John Wiggins,
The University of Georgia

The increasing cultural diversity in science classrooms demands research on students from underrepresented groups in the sciences. Research has determined several cognitive factors that are significant to African American middle grades students with highly positive attitudes toward science. From a sample of 2,288, data from a group of sixth, seventh, and eighth grade students classified highly positive in the area of attitudes toward science demonstrated significant correlations between attitude toward teacher, science self-concept, and science achievement motivation. In addition to the above results, sixth grade students attitudes toward science significantly correlated with the science curriculum. Sixth and seventh grade students had significant correlations between family attitudes toward science and studnet's attitudes toward science. These results indicate that affective characteristics that urban African American middle school students bring into the classroom influence their attitudes toward science.

Symposium: Uses of Technology in Science Education Research
C6

TEXTBASE ALPHA: A QUALITATIVE MANAGEMENT PROGRAM.

Ron Browne and Charlene M. Czerniak, The University of Toledo

The purpose of this paper is to demonstrate Textbase Alpha, a qualitative management program, and explain how it was used in a study of preservice teacher self-efficacy. This program plays only a modest role in the analysis of qualitative data, compared with that of the researcher. The researcher, as with any qualitative study, must decide which analytical procedure to use, which part(s) of the data are relevant to the study, how to organize the data, and how to interpret it. However, Textbase Alpha limits many of the tedious tasks involved in qualitative research such as cutting, pasting, excerpting, and sorting. This program has three main operations: pre-coding, unstructured coding, and quantitative manipulation of qualitative material. Data can be pre-coded when the research contains structured data such questions considered one category. When data does not have have pre-structured categories, the researcher reads, "segments" text, and codes the segment with a word representing its meaning. The researcher can analyze the text by searching for words, discovering themes, explaining relationships, or conducting linguistic analyses. Finally, data can be formatted and transferred to SPSS for statistical analyses.

Symposium: Research on Science Teacher Education

D1-1

SYMPOSIUM: RESEARCH ON SCIENCE TEACHER EDUCATION

Ronald D. Anderson, University of Colorado
Carole P. Mitchener, DePaul University
Susan Loucks-Horsley, The Network

Three researchers will each address a different component of science teacher education: theoretical perspectives (Anderson), the curriculum of preservice science teacher education (Mitchener), and staff development (Loucks-Horsley). Michael Padilla will serve as the discussant.

Paper Set: Metacognition in Science
D1-2

Reading Comprehension and Metacognition in Science: A Overview.
Larry D. Yore, University of Victoria

This paper set is designed to summarize the progress made in reading comprension since 1985 and to outline the parallels between reading comprehension research and contemporary science education research. The interactive-constructive models of reading and science learning have several unifying characteristics. Schema theory, generative processes, episodic and semantic memories, strategic actions and metacognition arise in both reading comprehension and science education literature. These characteristics could provide an interesting perspective for future research. The paper set will summarize the reading comprehension research, report on two research studies and outline future potentials and directions. This is accomplished from consolidating the individual perspectives of reading educator, science educator, and french language educator.

Contributed Papers: Reasoning/Inquiry Learning
D1-3

REASONING USING BIOLOGICAL CONTENT: RELATIONSHIPS AMONG EVIDENCE, THEORY, AND INTERPRETATION

D1-3-1

Catherine L. Cummins, Ronald G. Good, Sherry Demastes, and Patsye Peebles, Louisiana State University

This study investigated student reasoning using biological content. Students were given a simulation involving island biogeography and were asked to explain the data in a "think aloud" interview. Research questions included: (1) What variables will students use to evaluate biological data?; (2) will students use the controlling variables strategy in this context?; (3) to what extent will students include the theory of evolution?; (4) will the number of biology courses taken have an effect on the evaluation of evidence?; (5) what effect will a researcher-introduced theory have on the interpretation of the data? These questions drew on the theory base involving formal reasoning, confirmation bias, problem solving, and misconceptions. Thirty high school and college Zoology students were part of a theoretical sample. Nine categories of variables emerged from the data. The most often used variables, in descending order of occurrence, were (a) size, (b) distance, (c) human activity, and (d) habitat. Very few subjects considered time (evolution) as an important variable. Most students concentrated on one variable and did not try to establish whether another variable might have more effect. Students used strategies to "explain away" evidence that conflicted with their hypotheses. The effects of content on reasoning will need additional research in a variety of domains.

D1-3-2

THE RELATIONSHIP BETWEEN ANTHROPOMORPHIC/TELEOLOGICAL REASONING, AGE, AND THE STUDY OF BIOLOGY

Anat Zohar, Yael Friedler, and Pinchas Tamir, The Hebrew University of Jerusalem

The purpose of this study was to investigate whether there are developmental differences in teleological and anthropomorphic reasoning and whether biology students differ from non-biology students in teleological and anthropomorphic reasoning. The 168 high school and university participants responded to a Microcomputer-Based Interactive Test (MBIT) which identified their anthropomorphic/teleological versus causal reasoning patterns. The findings of the study indicated that maturation contributes to the development of causal, non-teleological reasoning between tenth and twelfth grade. It was also shown that the study of biology is a major factor influencing the ability to distinguish between teleological and causal non-teleological reasoning. The educational implications of the study refer to the need to deal with the issue of causal, non-teleological reasoning explicitly and repeatedly during the study of biology.

THE DEVELOPMENT OF THINKING IN EARLY ADOLESCENTS

D1-3-3

Richard L. Williams, University of Victoria, and Betty L. Bitner, Southwest Missouri State University

The purpose of this paper was to develop a theory of cognitive development consistent with recent research results. These research results show a distinct plateau in the development of reasoning in adolescents as measured by the GALT instrument. The work builds on the neo-Piagetian frameworks and applies specifically to adolescents between the ages of 12 and 15 years of age. The theory explains why some adolescents appear to regress in their reasoning abilities over a period of several months and indicates how teachers need to be aware of the implications of this phenomenon. Suggestions for further research to test this hypothesis are indicated.

A TEACHER'S PERSPECTIVE OF THE IMPLEMENTATION OF PROBLEM-CENTERED LEARNING IN CHEMISTRY

D1-3-4

Nancy T. Davis and Maggie Helly, Florida State University

The purpose of this study was to develop an understanding of teacher change from the teacher's perspective. A teacher-researcher and a university-researcher collaborated in this on-going study of change as the teacher attempted to design and implement problem-centered learning in her high school chemistry classes. Findings report both internal (individual) and external (cultural) constraints to change as well as factors which facilitated the change process. Issues associated with conducting collaborative research with teachers including philosophical, ethical, and methodological issues are discussed.

Contributed Papers: Qualitative Research
D1-4

MICROCOMPUTER APPLICATIONS FOR DATA GATHERING AND DATA ANALYSIS IN QUALITATIVE RESEARCH D1-4-1

Patricia E. Simmons, University of Georgia.

Microcomputers and appropriate instructional software have the potential to help students learn concepts and develop problem-solving skills and can serve a critical role in qualitative research as data generators, data collectors, and data analyzers. The principal objective of this series of studies was to examine, extract, and analyze common and unique problem-solving characteristics and patterns of subjects who were expected to perform successfully when solving problems. Microcomputer simulations based on general problem-solving and genetics were selected as the vehicles with which to examine subjects' genetics concepts and problem-solving strategies. These simulation programs allowed users to specifiy particular systems to investigate by selecting various parameters. The principal microcomputer software employed in multiple data coding and analysis was HYPERQUAL. The results of these studies have led to the formulation of a problem-solving model which is based upon learners' interaction with a simulation where they control which variables to manipulate, which models to construct, which problem solving strategies to test, and which scientific data from the computer program to extract for generalizations about principles and patterns governing their model.

QUALITY OF QUALITATIVE RESEARCH: A RATIONALE FOR CASE STUDY RESEARCH D1-4-2

Deborah J. Trumbull, Cornell University and Debra Tomanek, North Dakota State University.

In this paper presentation we examine the nature of case study research in science education by discussing core theoretical issues and illustrating these with some of our research. The impetus for the paper arose from our concern with recent work that claims to be case study research yet has not taken account of what we feel the requirements and strengths of case study are. When people do not make clear the foundational assumptions that are at issue, they easily end up doing case studies that duplicate traditional experimentally-based research, but now using interview or observational data. Traditional research is based on a Humean notion of causation that holds that casual statements are only statements of observed regularities. This notion of causality has led many education researchers to look for lawlike relations between variables. Case study research is based on scientific realism, which holds that there are underlying mechanisms operating in a bounded system. A well-done case study should explicate these mechanisms. Failure to address the different assumptions about causality leads to case studies that neither identify mechanisms nor explore the relations between specified variables, hence generate little knowledge of general use.

A CASE STUDY OF PEER REVIEW AT THE TERTIARY LEVEL

D1-4-3

Campbell J. McRobbie, Centre for Mathematics and Science Education, Queensland University of Technology.

This research reports a case study approach to a staff development initiative of tertiary lecturers. The initiative involves an action research approach using the clinical supervision model as the mechanism to promote teacher reflection and collaboration with their peers. While this approach has been extensively applied at school level, it has not been commonly investigated at the tertiary level. The study adopted a Schonian view of reflection to investigate the issues on which collaborative discussion occurred, what aspects of those discussions were reflected upon and the initiators and barriers to reflection. This analysis showed that this model of staff development was a powerful approach to initiating change towards the development of the reflective practitioner.

D1-4-4

ASSESSMENT OF CHILDREN'S HANDS-ON EXPERIMENTAL WORK: A DESCRIPTIVE APPROACH

Anthony W. Bartley and Robert Carlisle, University of British Columbia, and Ruth Stavy Tel Aviv University

The 1991 British Columbia Science Assessment included a practical component. It has now become policy in B.C. that 'curriculum and assessment should be learner focused'. This paper set will describe the development of such a learner focused assessment through the active involvement of students in experiments. The first paper deals with the development of items, their sources, our criteria for selection and piloting in schools, administration procedures and associated teacher professional development, and the analytical framework. The second paper examines the results of the assessment at three levels, individual, school and provincial. Three main issues are addressed, developmental, within-grade consistency across objectives, and gender.

Contributed Papers: Instructional Media/Technology
D1-5

D1-5-1

A PROTOCOL ANALYSIS OF THE EFFECT OF TECHNOLOGY ON STUDENTS' ACTIONS, VERBAL COMMENTARY, AND THOUGHT PROCESSES DURING THE PERFORMANCE OF ACID-BASE TITRATIONS.

Mary B. Nakhleh, Purdue University and Joseph S. Krajcik, University of Michigan

We investigated students' thought processes and actions during acid-base titrations. Different levels of information were presented by three technologies: chemical indicators, pH meters, and microcomputer-based laboratories. We hypothesized the level of information would influence students' actions and thought processes, as expressed in verbal commentary. We investigated students' pre/post understanding of acid-base concepts and concurrent thought processes and actions while titrating. Here we reports students' actions and thought processes while titrating. Data were collected from fifteen secondary chemistry students. Each student used one technology to titrate a strong acid, a weak acid, and a polyprotic acid with a strong base. They verbalized their thoughts while titrating. Students then graphed pH vs. volume of base and discussed the titration with the first author. Verbal commentaries were coded and analyzed for patterns in actions and for frequency of statement categories. Drawings were analyzed for shape, scale, and direction; discussions were analyzed for understanding of acid-base neutralization. We found the technology's level of information affected the focus of students' observations. The microcomputer group focused only on the graph; other groups exhibited multiple foci. We speculate the screen display functions as an auxiliary short-term memory.

D1-5-2

THE EFFECTS OF QUESTIONS EMBEDDED IN SCIENCE VIDEOTAPES ON HIGH SCHOOL STUDENTS' ATTENTION

Laura M. Barden, The University of Tennessee, Knoxville; William G. Holliday; The University of Maryland at College Park; James Carifio, The University of Massachusettes at Lowell; Wm. J. Kermis, Southwestern Oklahoma State University.

Two experiments were conducted to determine the differential learning effects of questions embedded in science videotapes on high school biology students. Three single-topic, commercially available videotapes were used—the three topics included digestion, atomic energy, and population cycles. In both experiments, subjects were randomly assigned to one of four treatment groups (which included two lower-order and two higher-order question groups) or one of three control groups. In Experiment 1, the 307 subjects completed an orientation session, viewed the population cycle videotape, and then completed two posttests—a free-verbal-recall and a cued-recall test. A different group of 316 subjects participated in Experiment 2. They completed an orientation and viewed three videotapes during a three day period. After viewing the third videotape (population cycles), subjects completed a free-verbal-recall and a cued-recall test for the third videotape. The results of those experiments suggested that questions inserted after segments of a videotape tended to influence subjects' recall of question-related information but not their recall of non-question-related information. The results also suggested that the level of subject responses, not necessarily the level of the questions, tended to produce qualitative differences in attention and encoding.

USING NETWORK COMMUNICATION TECHNOLOGY IN SCIENCE TEACHER EDUCATION FIELD SETTINGS

D1-5-3

Dennis W. Sunal, Cynthia C. Sunal, and David Hedgepeth, University of Alabama, Tuscaloosa, 35487.

An investigation was conducted on the adaptation and use of network communication technology as a social process and as educational enhancement in a teacher education program. As a social process the research considered the impact of network technology on professional communication at teacher education field placement sites differing in facilitative support. As enhancement, communication and science lesson planning performance were considered. Fifty-eight novice elementary teachers were selected for control and experimental groups. Ease of contact and novice teacher attitudes were factors in the type and frequency of the clinical site communication related to science teaching. The administrative managers of the setting and the type of facilitation given were primary factors related to the quality of communication enhancement effects in the science teaching experience. Implications for teacher education programs will be discussed.

D1-5-4

PHASE II: A LONGITUDINAL STUDY ASSESSING THE EDUCATIONAL IMPACT OF A LEVEL ONE VIDEODISC-BASED ELEMENTARY SCIENCE PROGRAM

Lowell J. Bethel, James P. Barufaldi, Gayle V. Davidson and Anchir A. Syang, The University of Texas at Austin.

Determining the educational importance and impact on students of a level one videodisc based program in elementary school science was the primary focus of this study. More than 17 school systems, 37 teachers and approximately 1,100 students (N = 1,090) participated in the study over a two year period. This report focuses on the second year of a longitudinal study in which it was found that use of the Windows on Science Program did result in significant amounts of science being taught weekly, increased teacher enthusiasm (i.e. prevented burnout), improved students' attitudes toward science and technology, and significantly improved student achievement in science. The level one videodisc-based elementary science program was effective in improving science skills and knowledge and it was judged to be user friendly for instructional purposes by teachers who piloted the program over a two year period.

Contributed Papers: Student Conceptions/Learning
D1-6

D1-6-1

FACILITATING SUCCESS IN ATTAINING SCIENCE STUDENT OUTCOMES: CONSTRUCTIVIST CONSTRUCTS AND INVENTIONS APPLIED TO SCIENCE CURRICULUM AND INSTRUCTION.

Robert J. Stahl, Arizona State University.

The purpose of this paper is to provide a detailed description of the major assumptions, constructs, and principles of the Information-Constructivist perspective and detail its direct applications to science curriculum, instruction, and assessment aligned with expected student outcomes. The focuses are answering critical questions asked of the constructivist, clarifying the details of this unique constructivist perspective, and providing guidelines concerning its application to teaching. The structure of the paper will center around answering a series of questions. A major part of the paper will describe the theoretical construct labeled the "constructivist perspective" followed by representative sets of essential assumptions, concepts, terms, principles, and implications. One important role of the paper will be to clarify notions of constructivism, especially one version of constructivism. This is a theoretical paper with practical applications.

A STUDY OF THINKING AND LEARNING IN ELECTRIC CIRCUITS

D1-6-2

Hans Niedderer, University of Bremen, Germany
Fred Goldberg, San Diego State University, USA

Our learning process study with three college students focused on a microanalysis of thinking and learning during an open-ended instructional unit of electric circuits. A locally developed computer-video software program using a pressure representation of potential was used to provide students with a tool to develop their own ideas in the context of predictions and explanations of experiments with batteries and bulbs. The whole process of six sessions was videotaped and transcribed. The qualitative interpretive analysis showed an interesting thinking and learning process varying between an everyday life view based on "local reasoning" and a science view involving causal reasoning using OHM's p-prim. Results are presented in terms of a list of "cognitive elements" as our constructions to explain students' way of thinking.Also, a description of the final state of learning is presented together with evidence from many statements of students and selected video tape segments.

A DEVELOPMENTAL ANALYSIS OF STUDENTS' CONCEPTIONS ON SHADOW FORMATION.

D1-6-3

HSIANG-WU HUANG
Department of Physics
BAO-TYAN HWANG
Department of Chemistry
National Taiwan Normal University

In this study, diagnostic group tests for investigating students' conceptions on shadow formation were designed based on Piaget's original clinical procedures. More than four hundred students, including high school students, non-science and science major college students, were tested by using these instruments.

Various misconceptions as pointed out by previous investigators were confirmed and new features were also discovered among our subjects. The insight meaning and developments of these conceptions were studied statistically and analysed from a Piagetian view of operational thinking. Three developmental levels were found.

The correlations of these conceptual levels and the general cognitive developmental stages, as indicated by the abilities of weight and volume concepts, were also statistically investigated. The levels of shadow formation were found to be highly dependent on these cognitive stages.

The meanings of these findings to the teaching and learning were also discussed.

D1-6-4

THE DEVELOPMENT OF FIRST GRADERS' IDEAS ABOUT METAMORPHOSIS: THE ROLE OF FORMAL AND INFORMAL LEARNING.

Daniel P. Shepardson, Purdue University.

This investigation involved a case study of children's (First grade) ideas of metamorphosis, the origin of their ideas (informal learning), and the effect of formal learning experiences and small group interactions on their understanding of metamorphosis. The instructional approach was based on the Generative Learning Model (Osborne & Freyberg, 1985).

Findings suggest that children's initial understanding of metamorphosis was incomplete and restricted to their prior, informal experiences. Assimilation was promoted through anchoring formal learning experiences to the child's existing ideas; and by providing additional, but contextually different experiences with the phenomenon. Small group interactions focused on the negotiation of materials and status versus a sharing or negotiation of meaning. Teacher intervention, as an authority, promoted negotiation of meaning with children, versus the negotiation of a consensual meaning among children.

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Contributed Papers: Computer Education
D1-7

THE EFFECTS OF COMPUTER ANIMATION EMPHASIZING THE PARTICULATE NATURE OF MATTER ON THE UNDERSTANDINGS AND MISCONCEPTIONS OF COLLEGE CHEMISTRY STUDENTS. D1-7-1

Vickie M. Williamson and Michael R. Abraham, University of Oklahoma.

This study explores the effectiveness of a visual aid on students' comprehension of chemistry concepts involving the particulate nature of matter. The lack of understanding of these concepts may be linked to the students' inability to visualize particulate behavior. With the new technology of computer animation, dynamic and three-dimensional presentations are possible. Animations were used in two treatment situations: 1) as a supplement in large group lectures and 2) as both the lecture supplement and an assigned individual activity in a computer laboratory. These two experimental treatments were compared to a control group. Four dependent variables were measured: conceptual understanding, the number of students holding misconceptions, course achievement, and attitude towards instruction.

STRATEGIC SIMULATIONS IN UNDERGRADUATE BIOLOGY: AN OPPORTUNITY FOR INSTRUCTION. D1-7-2

Angelo Collins, Florida State University and Doug Morrison, Rutgers University-Newark.

The purpose of this study is to describe 1) the transmission genetics content knowledge (conceptions and misconceptions) and 2) the genetics problem-solving strategies of 504 students in an undergraduate introductory biology course. Using the computer program GENETICS CONSTRUCTION KIT (GCK) the students solved a single simple-dominant problem in transmission genetics and wrote a letter explaining the solution and how they arrived at it. Sixty-eight percent of the students presented a correct solution. While previously identified misconceptions, such as the equivalence of dominance and frequency, were revealed, new misunderstandings were uncovered, such as varied forms of dominance and the function of Chi-square. The paper concludes with suggestions for knowledge restructuring towards opened-ended problem solving and with recommended instructional strategies.

THE LEARNING ENVIRONMENT AS A FOCUS FOR THE EVALUATION OF INQUIRY-BASED COMPUTER CLASSROOMS.

D1-7-3

Dorit Maor and Barry J. Fraser, Curtin University of Technology, Perth 6001, Western Australia.

This paper examines the perceptions of 120 students and six teachers of the learning environment in seven inquiry-based computer classrooms. The subjects responded to the Computer Classroom Environment Inventory (CCEI) before and after using a computerized database *Birds of Antartica*. The database, which was used for two school terms, has the potential for helping students to develop a wide range of inquiry skills. Generally, there was a significant increase in students' perceptions on the Investigation and Open-endedness scales of CCEI after using the database. A comparison of teachers' and students' profiles of perceptions at the completion of the program showed a similar trend. However, teachers' perceptions of the actual (post) classroom environment was more positive than those of the students on three of the scales of CCEI: Open-endedness, Organization and Material Environment. Other aspects of the evaluation not reported in this paper involved assessment of student achievement on inquiry skills tests and a qualitative interpretive investigation of the processes involved in learning science in inquiry-oriented and computer-based environments. Overall the different aspects of the study provided complementary insights into learning in a context which was designed to emphasize both a constructivist approach and higher-level outcomes.

D1-7-4

USING MICROCOMPUTER SUPPORTED INSTRUCTION TO MEET DIFFERING LEARNING MODES.

Carl Berger and Charles Dershimer, University of Michigan.

The purpose of this study was to find and describe variables of use as students became more familiar and successful with a microcomputer supported chemistry instructional program. A multimedia interactive software package was used as the learning environment. The package contained screens of information in text and picture form, animation, simulation, video segments, focus questions, inquiry questions and an organizing concept map. Students could navigate by clicking on icons that initiated the next event or state of learning. Data were gathered automatically in log files and over 2,250 state changes were analyzed for 10 students having two experiences with the program. Results indicated that students varied widely in using the materials and with experience students moved from lower order skills of text/picture information and focus questions to higher order skills such as inquiry questions and use of concept maps. Such multimodal learning tools can provide opportunities for students with wide differences in learning style. The implications of the research are that such sophisticated programs can provide high level learning. Instructors using such tools can be more confident that differing student learning needs are being met by supplementing their classroom experiences with multimedia interactive software programs for students.

Discussion Group: Teacher Beliefs/Knowledge-Secondary
D2-1

PRESERVICE SCIENCE TEACHERS' CONCEPTIONS OF SUBJECT MATTER AND PEDAGOGY: A LONGITUDINAL STUDY OF PROFESSIONAL DEVELOPMENT. D2-1-1

Norman G. Lederman, Oregon State University, Julie Gess-Newsome, University of Utah, Mark Latz, Oregon State University

The purpose of this study was to assess the development and changes in preservice science teachers' subject matter and pedagogy knowledge structures as they proceeded through their professional teacher education program and student teaching experience. Twelve preservice science teachers were asked to create representations of their subject matter and pedagogy knowledge structures periodically (four times spanning the entirety of their subject-specific teacher education program) and participate in a videotaped interview concerning the eight representations immediately following student teaching. Qualitative analyses of knowledge structure representations and transcribed interviews within and between subjects were performed by one of the researchers and "blindly" corroborated by the other two. Initial knowledge structures were not coherent and typically linear. Both types of knowledge structures were highly susceptible to change as a consequence of the act of teaching. Although there was some overlap between the two types of knowledge structures, they were seen to exert separate influences on classroom practice with the pedagogy knowledge structure having primary influence on instructional decisions. Implications concerning the interaction of knowledge structure complexity and translation to classroom practice as well as the construct of pedagogical content knowledge are discussed.

TEACHERS' PERCEPTION OF CONCEPT MAPPING AS A METALEARNING TOOL IN SCIENCE: A CROSS-NATIONAL STUDY D2-1-2

Peter Akinsola Okebukola, Lagos State University, Lagos, Nigeria
Olugbemiro J. Jegede, University of Southern Queensland, Australia

Sparse literature exists on how science teachers are disposed to the technique of concept mapping. The purpose of this study was to find out the perception of teachers on four aspect of the concept-mapping heuristic. These were: (1) learning how to make concept maps by teachers; (2) teaching concept mapping to students; (3) useability by students; and (4) perceived benefits of the heuristic. 135 biology, chemistry and physics teachers from Australia, Indonesia and Nigeria were surveyed. Data collected using the Attitude Toward Concept Mapping Inventory showed that all the teachers were favorably disposed toward concept-mapping as a metalearning tool in science. No significant inter-country differences emerged. Biology teachers of the three groups, found concept mapping to be easiest to learn. All the three groups of teachers (biology, chemistry and physics) (a) did not find concept mapping too abstract to learn; (b) were in agreement that you need not be very intelligent to learn the strategy; and (c) indicated that their students are likely to demonstrate greater understanding of the subject when they start using the technique. Implications for further research on concept mapping and classroom practice are drawn.

D2-1-3

USE AND EFFECTIVENESS OF DAILY JOURNAL WRITING WITH PRE-SERVICE TEACHERS

Patricia L. Hauslein and Patricia R. Simpson,
St. Cloud State University

The purpose of this study was to determine the effects of journal writing on participant 1) introspection as teachers and learners, 2) self confidence, 3) sense of professionalism, and 4) understanding of the nature of science and technology. The effect of teacher comments on participants' willingness to engage in reflective thought was also examined. Three groups of preservice science teachers were used at various stages in their program. Both qualitative and quantitative measures demonstrated the effectiveness of journals in this study.

D2-1-4

CHANGES IN SCIENCE TEACHERS PERCEPTIONS OF SPECIFIC TEACHING SKILLS AND STRATEGIES: A LONGITUDINAL STUDY.

Roger A. Norris, The University of Idaho

The purpose of this study was to measure changes in the perceived value of twelve teaching skills and strategies typically addressed in a science teacher preparation program. Data were gathered from twenty-seven individuals first while they were engaged in a teacher preparation program, then again after they had accumulated up to three years of classroom teaching experience. Results indicated that experienced teachers rated skills and activities involving direct classroom interaction with students more highly than they did initially, and that they rated lesson planning, sequencing, and content knowledge lower than they did initially.

D2-1-5

THE ROLES OF THREE TYPES OF TEACHER KNOWLEDGE--CONTENT KNOWLEDGE, PEDAGOGICAL KNOWLEDGE, AND PEDAGOGICAL CONTENT KNOWLEDGE--IN THE TEACHING OF HIGH SCHOOL MENDELIAN GENETICS

Mary Louise Bellamy, NABT; Hilda Borko, Univ. of Colorado; David Lockard, Univ. of Maryland

This study examined the genetics, pedagogical, and pedagogical content knowledge of four high school biology teachers in relation to the understanding of some of their students. Research has not been conducted previously which examines relationships among teacher science knowledge and student understanding. Teachers who knew genetics very well were observed and interviewed as they taught a unit in genetics. Several students of each teacher were tested at the beginning and end of the unit to determine their change in genetics knowledge, the final test requiring them to think aloud and answer written and oral questions. Qualitative methodology was used to analyze data. Results indicate that (a) teacher content knowledge alone is not enough to facilitate student understanding, and that intervening mental processes involving PK and PCK are required, and (b) differences exist in the PK and PCK of experienced teachers of genetics.

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Discussion Group: Science Teacher Preparation
D2-2

D2-2-1

RESULTS OF A SURVEY OF SECONDARY SCIENCE METHODS COURSES IN OHIO, ILLINOIS AND INDIANA

Steven W. Gilbert, Oakland University

This study was undertaken to examine the characteristics of secondary science methods courses and methods course instructors in colleges and universities in Ohio, Illinois and Indiana. Results provide a profile of methods course distribution and content. Three categories of science methods instructors were identified. Differences between the groups are discussed along with general implications of the study.

D2-2-2

TRIADS: A COLLABORATIVE APPROACH TO THE PREPARATION OF SCIENCE TEACHERS IN THE UNITED STATES AND ISRAEL

Cheryl L. Mason, San Diego State University
Jehuda Huppert, University of Haifa

Teacher preparation programs often have been criticized for unilaterally stressing either content or pedagogy, rather than a blending of the two. Teaching so that meaningful learning can occur requires a true understanding of the interconnectedness of content knowledge and learning theory - *science-specific pedagogy* . It was the acquisition of this critical type of knowledge that led to the formation of the United States TRIAD teaching teams consisting of a high school teacher, a professor either in biological sciences or physical sciences, and a professor in science education. This four-year project sought to develop and determine the effectiveness of the TRIAD's endeavors to expose students to the multiple facets of science and science education. The philosophy of the TRIAD approach at San Diego State University helped inspire the development of a new model of teacher preparation at the University of Haifa-Oranim. At both sites, data collected via interviews, concept mapping, journal entries, class assignments and observations reflected the positive impact of this collaborative approach to teacher preparation.

EDUCATING URBAN AT-RISK STUDENTS: A NEW APPROACH TO TEACHER EDUCATION IN MATHEMATICS AND SCIENCE **D2-2-3**

P.F.Abder, G.Orpwood and V.Svolopoulos,
New York University

The purpose of this paper was to describe the development, implementation and evaluation of a science and mathematics teacher education program at an urban university. Initial development involved the compilation of a databank and a needs assessment which informed the program content. The program focused on developing appropriate strategies for teaching science and mathematics to students from diverse and multicultural communities with a large percentage of female and at-risk students, and exposing science and mathematics teachers to personal experience of the scientific enterprise. Program evaluation included attitude scales and observation checklists for teachers and attitude and achievement scores for students. Results indicated that both groups benefited significantly from the experience.

D2-2-4

ON THE FOAD TO EXPERT SCIENCE TEACHING
STUDENT TEACHER-PUPIL INTERACTIONS

Gail Jones and Elizabeth Vesiland, University of North Carolina-Chapel HiU.

The purpose of this exploratory study was to examine student teachers' interactions over the course of a ten-week student teaching experience to determine if interactions changed over time and to compare the frequency of interactions with those of experienced teachers. Fifteen middle grades teachers were observed for six weeks with the Brophy-Good Teacher-Child Dyadic Observation System. Frequencies of interactions were obtained, and patterns across three time periods were analyzed. Results of the study revealed significant differences across three time periods for student-initiated interactions and procedural questions. A U-shaped developmental pattern emerged for seven of the eight variables; This pattern emerged across the four different content areas, regardless of the place of the lesson in the unit plan.

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D2-2-5

A PROGRAM TO IMPROVE ELEMENTARY TEACHERS' PREPARATION IN SCIENCE, PHASE II.

Eileen Gregory and Linda DeTure, Rollins College

The purpose of this project was to develop a model for teaching science to pre-service and in-service teachers that would enhance their content background and improve their attitudes toward science. Four departments (Biology, Chemistry, Physics and Education) combined efforts to re-design the science program for elementary teachers at Rollins College by developing and implementing a new sequence of science courses. The Phase I courses included a science content course integrating biology and chemistry and a corresponding science methods course. The second phase included the development of a content course integrating the principles of earth science with physics and an expansion of the social studies methods of 0.5 course units to 1.0 course unit to incorporate sections related to geography and the environment. Pretest-posttest analysis showed success in increasing the students' knowledge in basic concepts for all the courses developed, as compared with students enrolled in science courses designed for non-science majors. The first set of courses have been revised and the second set are being revised to achieve greater success in improving science background and attitudes towards science and science teaching. The set of courses have become a part of the regular curriculum for undergraduate pre-service elementary teachers.

D2-2-6

COMPUTER USES IN SECONDARY SCIENCE LABORATORY: PROJECT DESIGN, IMPLEMENTATION AND EVALUATION

Deborah J. Trumbull Cornell University, John Schwartz Ithaca College, Nancy Ridenour Ithaca High School

The presentation will describe a very successful NSF-funded summer program at Ithaca College that has run for three years. The intent of the project was to introduce high school teachers to the uses of computers in secondary science laboratory teaching. Workshop participants learn to use computers to run statistical programs to analyze experimental data or to program computers to work with data-gathering interface devises they built. One of the project organizers will describe a brief history of the project and explain how the focus decisions were made. One of the project staff teachers will describe implementation various that arose in the school and the ways the project solved them. The project evaluator will indicate the data that indicate that the project was highly successful and identify some of the variables that contributed to that success. These include project design decision and teacher's conceptions of science laboratory skills.

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A PRELIMINARY STUDY OF THE EDUCATIONAL OUTCOMES OF TEACHER SUMMER INTERNSHIPS

D2-2-7

Teri Metcalf and Robert K. James, Texas A&M University

The purpose of this study is to assess the educational outcomes of teacher summer internships in terms of teacher beliefs about how the experience will impact their classroom teaching. The internship program assessed in this study is the Teacher-in-Industry program which is coordinated by the Texas Alliance for Science, Technology and Mathematics Education. This study compares the outcomes of teacher participants with a group of teachers not selected to participate in the program. Beliefs and attitudes were measured on a 15 item Likert scale instrument designed by the authors. Preliminary findings are based on 18 instruments returned from the participant group and 14 from the reference group. Preliminary findings show an increase in means (between pre and post) for the participant group, and a decrease for the reference group. This suggests that the teacher summer internship program has had a positive impact on teacher beliefs and attitudes about their teaching. In a post evaluation, teacher participants give the program high ratings in terms of the internship experience, educational outcomes and classroom transfer. Preliminary findings of this study suggest that summer internships have significant educational outcomes in science, technology and mathematics, and are an important form of professional development for teachers.

D2-2-8

EFFECTIVE MEASUREMENT OF AFFECTIVE OUTCOMES IN CURRICULUM EVALUATION

Léonie J Rennie, Curtin University of Technology

An instrument measuring students' attitudes and perceptions about technology was used in separate evaluations of two technology curriculum projects. Its use was effective in an evaluation of curriculum materials to teach technology to grades 5 to 7, but not effective in an evaluation of a program to introduce technology education into the curriculum of six high schools. The effective measurement in the first evaluation was attributed to the project's clear statement of intended affective outcomes, enabling the instrument to be designed to match the questions guiding the evaluation. Intended affective outcomes were not clearly stated in the second evaluation and, although the instrument appeared to be appropriate, no interpretable pattern of change emerged. This result could mean either that the program was unsuccessful in changing students' attitudes and perceptions about technology, or that the instrument did not measure those variables which more appropriately reflected the outcomes of the program. The findings indicate that effective measurement of affective outcomes is more likely when intended outcomes are clearly articulated and when program outcomes and measures are demonstrably matched.

Discussion Group: Conceptual Change
D2-3a

THE EFFECTIVENESS OF DIFFERENT TEACHING MODELS FOR SCIENCE CONCEPTUAL CHANGE

Meme Dai, Taipei Municipal Teachers College
Joseph Riley, University of Georgia

D2-3a-1

This investigation is a follow-up study of the identification of misconception about the moon held by 5th and 6th graders in Taiwan. The purpose of this investigation is to determine whether using focused teaching materials designed to present accurate scientific concepts and using effective teaching models will result in children changing their misconceptions related to the moon. Two intact classes were assigned as experimental group that received role-playing instruction. The other two intact classes were assigned as control group that received lecture-oriented instruction. The instructional treatment was conducted over 2 weeks at 4 elementary schools in Taipei, Taiwan. The previously developed IMMI was used as a diagnostic instrument for pre- and post-tests. Results indicated significant increases on both posttests. However, the experimental group was significantly gain better than the control group. The results also shown that the boy did not learn the moon concepts as taught better than girls and that the interaction of sex and treatment is not significant. How the students' misconceptions about the moon have been changed to accurate conceptions were stated. It was concluded that role-playing teaching model is highly recommended for teaching the movement of the sun, earth and moon.

ORIGIN OF ALTERNATIVE CONCEPTIONS: SOME NOTES FROM CROSS-CULTURAL RESEARCH

D2-3a-2

Euwe (Ed) van den Berg, Center for Development Cooperation and Services

Misconception surveys as well as some more in-depth interview studies were conducted by the author and students in Indonesia in various branches of Physics such as mechanics, electricity, heat and temperature, and optics. Results at secondary school and university levels show the same kinds of misconceptions and student reasoning as in western countries.

The results of these studies show a rather striking similarity in student (mis)conceptions across cultural and environmental boundaries and across education systems. Together with the results of studies of conceptions of physicists in history, results of cross-cultural studies suggest a rather minor role for cultural variables and (variation in) the man-made environment on the formation of Physics conceptions. This conclusion might be rather unexpected to those with experience in non-western cultures, as culture seems such a pervasive variable in human behavior and thinking.

Somehow the physics conceptions (including alternative conceptions) get abstracted out off complex mixtures of context- and culture-rich stimuli. This and some of the alternatives will be reviewed in the paper using the author's data.

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ALTERNATIVE CONCEPTIONS AS CATALYST FOR CONCEPTUAL CHANGE.
Randy McGinnis and Joseph P. Riley II, University of Georgia

D2-3a-3

The underlining assumption of this research is that awareness of alternative conceptions can inform and enhance instruction. The purpose of this study was to design an effective conceptual change teaching strategy using alternative conceptions as a catalyst for conceptual learning. The subject matter taught was the phase of the moon: a topic extensively documented in the literature as being one in which students hold various alternative conceptions. Guided by proponents of contructivist teaching, this research has achieved encouraging results that offer hope for classroom teachers searching for effective strategies to bring about conceptual change in subject matter.

THE RELATIONSHIP BETWEEN MENTAL MODELS RELATED TO THE PARTICULATE NATURE OF MATTER AND THE INFINITE NATURE OF GEOMETRICAL FIGURES

D2-3a-4

Dina Tirosh & Ruth Stavy, Tel Aviv University

In the course of a research project now in progress, three externally similar problems were presented to students in the 7th to 12th grades. The first problem concerned an ideal, geometrical line segment, while the other two dealt with material substances (copper wire and water). All three problems involved the same procedure: successive division. Two of the problems (line segment and copper wire) were also figurally similar. Our data indicate that the procedural similarity had a profound effect on students' responses, whereas the figural similarity affected responses to a much lower extent. The predominant effect of the procedural similarity suggests that the repeated process of division has a coerciveness effect that imposes itself on students' responses and encourages them to view successive division processes as finite or infinite regardless of the content of the problem.

Discussion Group: Textbook/Program Evaluations
D2-3b

FROM CONCRETE TO THEORETICAL: AN ANALYSIS OF TWENTIETH CENTURY, HIGH SCHOOL CHEMISTRY TEXTBOOKS

D2-3b-1

Lee Meadows, University of Georgia

This research analyzed high school chemistry texts spanning the twentieth century for growth in the amount of text and shift in focus from concrete to theoretical topics. Twenty-five texts were analyzed, ranging in publication date from 1902 to 1989. Analysis relied chiefly on the tables of content, using chapter text only when chapter titles were ambiguous. Total text area was also calculated. Results indicate a reversal in content focus during the twentieth century: Texts from the early 1900's focused 75% of their content on concrete or applied chemistry; texts from the 1980's focused 90-100% on theoretical topics. Text size tripled throughout the twentieth century.

TEACHING SCIENCEPLUS: AN OBSERVATIONAL SURVEY OF SCIENCE TEACHING IN NEW BRUNSWICK AND NOVA SCOTIA GRADES 7, 8 AND 9

D2-3b-2

Charles P. McFadden, The University of New Brunswick

An observational survey was conducted in 24 randomly selected schools in Nova Scotia and New Brunswick. These Canadian provinces are among the first educational jurisdictions in North America to have implemented a constructivist, STS curriculum in their junior high schools. Access was gained to 90% of the SciencePlus classrooms in these schools. 165 class periods of instruction from 63 teachers were observed.

A chronological record of classroom events was kept, with a focus on evidence of student engagement in meaningful learning. Every kind of learning activity observed was recorded and classified.

The report of this research includes frequencies and duration of the different forms of learning activity and kinds of classroom interaction that took place. An overall qualitative indicator of the observed classroom interaction was used. It was found that the average student in these classrooms was engaged over 70% of class time in educationally meaningful learning (defined somewhat narrowly to include activities that evidently facilitate concept and skill acquisition and/or engage the student in imaginative or critical thought).

CONTINUOUS INTEGRATED CURRICULUM EVALUATION: THE CASE OF THE ISRAEL HIGH SCHOOL BIOLOGY PROGRAM

D2-3b-3

Pinchas Tamir, Hebrew University of Jerusalem

The case of Israel High School Biology Program (IHBP) is especially suitable to serve as an example for the impact of integrated evaluation. Close to 100 evaluation and research articles were published during the 20 years of its existence in professional literature, mainly in the USA and the UK. A wealth of information may be found in sources such as the Biology Teachers' Bulletin which published more than 120 issues in the long lists of inservice courses, in e matriculation examinations, in the individual research projects of students and in the wealth of instructional materials for students and teachers.
This paper presents an overview of the published evaluation and research articles and shows the development of ideas, the solutions to problems, the impact of evaluation on practice and the interaction between evaluation and research.

Discussion Group: Instructional Media/Technology
D2-4a

D2-4a-1

COMPUTER INCLINATION OF STUDENTS AND TEACHERS IN RELATION TO THEIR STS VIEWS

Uri Zoller, Haifa University-Oranim, and Stuart Donn, University of British Columbia

The 'computer inclination' (CI) of 881 11th-grade students and of their 181 teachers in relation to their STS views was assessed in randomly selected high schools in British Columbia using a two-part questionnaire: a short, modified version of the Survey of Attitudes Toward Learning About and Working With Computers for the CI and a condensed form of the VOSTS Inventory for the STS views. Significant differences between the computer inclinations of non-STS STS and STS students and between the STS views of non-STS and STS-teachers and students in the "attitude" category were found, but there were no differences between other subgroups on these dimensions. Computer Inclination Indices (CII) and Science/Technology Indices (STx) have been defined and used for the elucidation of possible correlations between the CIIs and the STxs. It is argued that the CIs and STS views of both students and teachers should be assessed and taken into consideration by the educational policy makers and developers of future science curricula and teacher training programs, if the goals of the currently sought reforms in science education are to be attained.

D2-4a-2

SOFTWARE TOOLS TO ASSIST THE LEARNING OF SCIENCE AMONG HISPANIC STUDENTS.

Jaime Hernán Sánchez, Educational Computing Center, University of Antofagasta, Antofagasta, Chile.

The purpose of this study was to produce a science learning material we labelled GAMETO, a computer software to assist biology education at the secondary and tertiary level. The software integrated modern curriculum and instructional psychology views about the teaching and learning of science. The stages of design, develop, and evaluation of the software are fully analyzed on the basis of the methodology used to construct GAMETO. The implications for biology education are discussed in terms of improvement the teaching and learning of biology by making special emphasis on new approaches for learning concepts and processes involved in the biology of reproduction. Results indicated that it is possible to develop dynamic software to assist efficiently science learners in their understandings of basic concepts and processes in biology by implementing a new and modern tool to attain some critical biological learning objectives more meaningfully.

Discussion Group: School-Business Partnerships
D2-4b

A COMPARISON OF EDUCATIONAL PERSPECTIVES OF SCIENCE TEACHERS, INDUSTRY PERSONNEL INVOLVED IN A BUSINESS/EDUCATION PARTNERSHIP AND INDUSTRY PERSONNEL NOT INVOLVED IN A PARTNERSHIP. D2-4b-1

Glenda Carter and John Park, NCSU

The purpose of the study was to analyze the views of teachers and business people involved in a business/education partnership as well as those not involved in a partnership. All groups were surveyed to ascertain perspectives on the following: 1)Typical school day;2)Strategies used in teaching 3)Major educational deficiencies of those entering the workforce. Data analyzed to date indicates that these industry personnel involved in partnerships have a very clear understanding of the types of activities and teaching strategies that go in middle school and high school science classrooms. Educators and partnership industry personnel also listed the same educational deficiencies of those entering the workforce with no significant difference in the frequency of response. Additional data is now being collected from industry personnel in similar type of industry not involved in business/teacher partnership. Comparisons of the three groups will be made upon completion of data collection.

D2-4b-2

VALIDATION OF A SCHOOL-BUSINESS PARTNERSHIP PROGRAM

Suzanne Weber, SUNY Oswego
C. Thomas Gooding, SUNY Oswego
J. Nathan Swift, SUNY Oswego
Barbara Beyerbach, SUNY Oswego

The Project SMART "Kids at Work" program is a new model for cooperative partnerships between schools, industry and higher education to improve school science and mathematics instruction. In this program, a local business makes an industrial site available for visits by children at neighboring schools. A team of teachers, with support from business and the university, develop classroom activities to precede and follow field excursions. These activities are correlated with the elementary curriculum, and are explicitly designed to show how school science and mathematics are used by adults in the workplace. Staff development workshops are offered by project teachers at the industrial sites. This paper reports on the evaluation of the "Kids at Work" Program. Attitudinal data are presented from the New York State Elementary Science Program Evaluation Test, a survey of fourth grade students and their teachers, administrators, and parents); and the Science Utility Evaluation, an attitudinal instrument focusing on perception of past and future performance in science, perceived usefulness, and enthusiasm.

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Discussion Group: Grouping Instructional Settings
D2-5a

The Effect of Levels of Group Cooperation on Students' Achievement in Physical Science Laboratory **D2-5a-1**

Huey-Por Chang, Department of Physics, National ChangHua University of Education, Taiwan, ROC
Norman Lederman, Department of Science & Mathematics, Oregon State University, OR 97331

The purpose of this study was to investigate the effect of the levels of group cooperation on students' achievement during a series of physical science laboratory activities. Six intact seventh grade physical science classes taught by two teachers, with each teacher instructing three classes, were selected from two middle schools. For each teacher, one of the classes was taught with a traditional approach (no cooperative goal structure). The other two classes were assigned to a cooperative goal structure (role assignment and non-role assignment). There were no significant differences on the students' final achievement with respect to the three instructional approaches followed by each teacher. The teacher effect was more significant than instructional approach on managing, manipulating, observing, reading,a nd writing behaviors. No significant teacher effect was found for the other behaviors. Only one treatment effect was significant, writing behavior. In teacher A's classes, reading behavior predicted 21% of students' achievement. However, no significant correlations existed between the ten collaborative behaviors and students' achievement in teacher B's classes.

SCHOOLYARDS AS CLASSROOMS: A STUDY OF THEIR EFFECTIVENESS. **D2-5a-2**

Linda L. Cronin-Jones, University of Fla.

This study compared the effectiveness of traditional indoor environmental science instruction and outdoor schoolyard environmental science instruction. Four intact classes of third and fourth graders received no instruction, four classes received 10 days of traditional indoor instruction and four classes received 10 days of outdoor schoolyard instruction. A modified Solomon Four experimental design was used and post test scores on content knowledge and attitude measures were compared. Results indicated that students receiving schoolyard instruction learned significantly more than those receiving traditional instruction. Although both treatment groups developed more positive environmental attitudes as a result of instruction, no significant differences were found between the attitudes of students receiving schoolyard instruction and those receiving traditional instruction.

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WHAT IS HAPPENING INSIDE UNSTRUCTURED GROUPS? PATTERN AND TYPE OF VERBAL INTERACTIONS OF INTERMEDIATE STUDENTS

D2-5a-3

Catherine R. Conwell-Nesbit, Faye G. Humphrey, Jack Fleming, University of North Carolina at Charlotte

The pattern and the type of verbal interaction within unstructured learning groups was examined in this study. Who spoke and who was spoken to within the group was recorded. Twenty-eight students from seven intermediate grade level classrooms, grouped heterogeneously for gender and race, and homogeneously for their grade level and ability in science, were selected for observation. The students were videotaped while participating in a science lesson. Both qualitative and quantitative analyses were part of the research design. In general, the pattern and type of verbal interactions were not significantly different between males and females and between Blacks and Whites. An analysis of trends suggested that males talked more to males; females talked more to the group; and Black females interacted the most actively, both positively and negatively. Black females spoke more negatively to White males as well as the White males to the Black females. Finally, White males were spoken to the most and White females the least.

CREATIVE DRAMA AND THE ENHANCEMENT OF ELEMENTARY SCHOOL STUDENTS' UNDERSTANDING OF SCIENCE CONCEPTS.

D2-5a-4

Michael Kamen, Auburn University

Two elementary classrooms in which creative drama was used as a part of science instruction were studied. The purpose was to investigate creative drama as a teaching strategy to enhance student understanding of science concepts. The two teachers were former students of the researcher. They responded to a letter asking for volunteers to participate in the study. This qualitative study used four instruments to investigate the effectiveness of creative drama in the science classroom: (1) written tests for the students; (2) interviews with the students; (3) interviews with the teachers; and (4) direct observations. The results support the use of creative drama. The students improved on the content assessment. Both the students and the teachers reported benefits from the use of creative drama, including a better understanding of the concepts and improved motivation and interest in science. Recommendations include the incorporation of creative drama techniques in elementary science methods classes and continued research into the support needed by teachers to use creative drama effectively and appropriately in teaching science.

CHILDREN ATTENDING SCIENCE CAMP: THEIR HOME ENVIRONMENT

D2-5a-5

Christa R. Winter, Lewis and Clark College

The study examined the home environment of children who attended science summer camp. Of special interest were associations between the home environment and gender of the child, and the home environment and economic status of the parents. Interviews were conducted with 23 parents of seven to ten year old children. Questions focused on demographic information, parents' value of science, science orientation in the home, and parents' view on child development and camp experience. Interview data were analyzed via content analysis. Findings indicated a strong science orientation in the home. Parents valued science regardless of their level of education and income. Most parents were well-educated with a moderate to high socioeconomic status. Parents of less privileged children (all female) emphasized science learning and future science careers more than others. Gender differences pertained to developmental aspects and career options with girl's parents focusing on girl's academic development and science careers.

Discussion Group Teacher Beliefs/Knowledge: Elementary-Junior High School

D2-5b

PRESERVICE ELEMENTARY AND SECONDARY SCIENCE METHODS TEACHERS: COMPARISON OF FORMAL REASONING, ACT SCIENCE, PROCESS SKILLS, AND PHYSICAL SCIENCE MISCONCEPTIONS SCORES

D2-5b-1

Betty L. Bitner, Southwest Missouri State University

The purpose of this causal-comparative study was to compare reasoning level, ACT science, process skills, and physical science misconceptions of preservice elementary and secondary science teachers and to investigate gender differences. The stratified randomly drawn sample (N = 68) consisted of preservice elementary and secondary science methods teachers. During the first two weeks of classes, the GALT, TIPS II, and PST were administered. Seventy-six percent of the sample (85% of secondary and 68% of elementary) were formal reasoners. Only 39% of the preservice elementary teachers correctly answered item 27, an identifying and stating hypothesis objective, on TIPS II. Sixty-five percent or more of the preservice secondary teachers had correct responses to the TIPS items. Misconceptions in electromagnetic phenomena/electricity/light, motion, and mass were found most often. Significant two-way ANOVAs ($p < .01$) were found on the ACT Science in favor of the secondary teachers and on the PST in favor of males and secondary teachers.

THE RELATIONSHIP BETWEEN TEACHER CONTENT AND PEDAGOGICAL CONTENT KNOWLEDGE AND STUDENT CONTENT KNOWLEDGE OF HEAT ENERGY & TEMPERATURE

D2-5b-2

Shirley Magnusson, University of Michigan
Hilda Borko, University of Colorado
Joseph S. Krajcik, University of Michigan
John W. Layman, University of Maryland

This study examined the influence of science teacher content knowledge (CK) and pedagogical content knowledge (PCK) on student knowledge acquisition after teachers conducted instruction about heat energy and temperature. Transcripts from semi-structured interviews conducted at the beginning and end of the school year provided the sole source of data . The sample consisted of eighth-grade teachers (n=6) and one randomly-selected student from each of their classes (n=22). There was evidence of a relationship between teacher CK, PCK and student knowledge; however, the most straightforward finding was that students who experienced the most and least instruction emphasizing the distinction between heat energy and temperature exhibited the most and least improvement in knowledge, respectively. Nevertheless, the results were best explained by considering that changes in student knowledge were a function of specific instruction as well as teacher CK and PCK. When teacher knowledge was strong and activities about the distinction between heat energy and temperature were many, student knowledge improved; when teacher knowledge was strong but such activities were few, student knowledge did *not* change; and, when teacher knowledge was *not* strong, student knowledge did *not* improve, and in some cases decreased, regardless of the activities.

ACCEPTANCE AND RESISTANCE AS FORMS OF TEACHERS' PARTICIPATION IN CHANGE **D2-5b-3**

Roberto Monteiro and James Gallagher, Michigan State University

During the past four years, a new professional role -- the Support teacher -- has been implemented in four junior high schools as part of a restructuring program. Interactions among four junior high school science teachers about proposed changes in teachers' roles were studied, using an interpretive methodology. The study was done to explore the nature of their participation during this attempt at adding the support role to their professional roles. Techniques used included 1)document analysis, 2) participant observation of ongoing interactions, 3) open ended interviews, and 4) subjects' written or spoken reactions.. By studying two science teachers who were in the Support Teacher role, which also involved daily teaching responsibilities, and two teachers who were regular classroom teachers in the same schools as one of the Support Teachers, it was possible to penetrate the complexities involved in teachers' participation in both accepting and resisting to changes that were proposed by the project. The findings in this study may contribute significantly to the understanding of reasons for success and failure of attempts at change in science teaching.

D2-5b-4

THE PRESERVICE ELEMENTARY SCHOOL TEACHERS' ATTITUDE TOWARD SCIENCE TEACHING AND ITS RELATIONSHIPS WITH SELECTED VARIABLES

Tien-Ying Lee, National Taiwan Normal University

The purpose of this study is to understand preservice elementary school teachers' attitude toward science teaching and its relationships with selected variables. Selected variables included basic science knowledge, final grades of science courses, method course and student teaching, the number of science courses taken, gender, science process skills, scientific attitude, and reasoning ability. The 576 graduates from junior teacher colleges in 1990 were involved. Data were analyzed through frequencies, correlation and multiple regression. Results indicated that 90% of preservice teachers agreed with the importance and the nature of science. However, most of them were afraid of teaching science. Basic science knowledge, gender, scientific attitude are stronger predictors of preservice teachers' attitude toward science teaching.

D2-5b-5

A PRELIMINARY ASSESSMENT OF SCIENCE PROCESS SKILL ACHIEVEMENT OF PRESERVICE ELEMENTARY TEACHERS

R. Doran, SUNY at Buffalo, and L. DeTure, Rollins College, D. Radford

The purpose of this group of studies is to begin to analyze and assess the preservice elementary teacher's level of achievement in the kind of laboratory process skills that they will be expected to teach in the elementary schools.

As an outcome of a study conducted in Australia using the process skill practical tests to test grade 5 and 9 students, a group of U.S. researchers decided to explore the possibility of using the standardized set of tests to examine the preservice elementary teachers process skill development and to explore other variables such as the effect of elementary science methods courses, the relation with other standard tests and common misconceptions of preservice teachers.

Discussion Group: Problem-solving/Use of Analogies
D2-6

D2-6-1

GIFTED SEVENTH GRADE GIRLS' STRATEGIES ON A MECHANICAL DESIGN TASK.

Marilyn L. Fowler, Austin Independent School Dist.

A random sample of eight gifted seventh grade girls was selected for this descriptive investigation into strategies associated with success on a mechanical problem. Each girl was introduced to the Capsela Building Set and was then directed to "design and build a fan about twelve inches tall that will cool your face and roll around." Transcripts of thinking-aloud recordings were analyzed using a Problem Solving Analysis Guide developed by the researcher and, as a result, the most common problem solving strategies and skills the girls used were found to be Investigation, Trial and Error, Attention to Detail, Energy/Work Analysis and Use of Hints and Cues. After quantifying the number of times each strategy was used and comparing it to success with and timely completion of the task, it became evident that Attention to Detail and Energy/Work Analysis were strategies most associated with success on the mechanical design task.

D2-6-2

A MEANINGLESS BUT NONALGORITHMIC SOLVING COURSE: SOLVING A GRAPHING PROBLEM ABOUT OSMOSIS BY ANALOGY

June T. Zuckerman, Queens College-- CUNY

A meaningless solving course is independent of the solver's conceptual knowledge. This paper is the first to document a meaningless but nonalgorithmic solving course that generated a correct solution to an unfamiliar problem. This solving course is significant for two reasons. It demonstrates that (a) an unfamiliar problem need not be solved meaningfully to be solved correctly and (b) a meaningless solving course need not be algorithmic. This study was undertaken to constrain the meaningful solving of a graphing problem about osmosis. The solvers were 14 high school students. They were also novices, solvers unfamiliar with the problem. Each solver generated a think-aloud solving of the problem, a pencil-and-paper solution, and a retrospective report of the solving course. The data were used to assess respectively whether the solving course was meaningful, the solution was correct, and the solver was a novice with respect to the problem. Thirteen of the 14 solving courses were meaningful. The one meaningless solving course was primarily the execution of the heuristic solving a problem by analogy.

D2-6-3

AN EXPLORATORY STUDY: THE RECOGNITION OF PROSE STRUCTURES AND THE CONSTRUCTION OF GRAPHIC POSTORGANIZERS ARE MORE USEFUL IN COMBINATION THAN IN ISOLATION.

George F. Spiegel, Jr , Science Education Center, University of Texas at Austin

The purpose of this study was to measure change in recall and retention of science knowledge in community college Anatomy and Physiology students who participated in a 14 hour (8 week) study skills class. The class emphasized the recognition of the six common science textbook prose structures (cause and effect, classification, compare and contrast, enumeration, generalization, and sequence) and the construction of graphic postorganizers of the prose structures. A pretest, two immediate posttests, and a retention posttest were used to measure recall and retention. Results indicated that on immediate posttests students that actively construct graphic postorganizers of the prose structure recall significantly more content than those students (controls) that simply underlined, reread, or highlighted. On a three week retention posttest those students in the class retained significantly more of the material studied than the controls.

D2-6-4

PERFORMANCE ASSESSMENT: IMPLEMENTING THE TASSK MODEL FOR SEQUENCING INSTRUCTION IN SCIENCE PROBLEM SOLVING

Carol L. Stuessy and Gil Naizer, Texas A&M University

The purpose of this study was to integrate performance assessment in the design of a new model for sequencing science instruction and to evaluate the model's effectiveness in teaching problem solving. In line with the reforms occurring in curriculum, instruction, and assessment in science education, the TASSK model was designed to provide teachers with a framework to guide their decision making about instructional sequencing. The model incorporates performance assessment data to support the intuitive strengths and understandings of teachers in selecting contextually appropriate instructional sequences. Each lesson has a "novelty profile" determined by students' familiarity with the content, strategies, and context of the lesson. By manipulating the teaching methods associated with any of these dimensions, the teacher impacts the profile of the task. The TASSK model was used to design an instructional sequence for fifteen preservice elementary teachers to solve problems about flying objects. Three performance assessments and a transfer teaching task were piloted. Preservice teachers also were tested with traditional measures of science content and strategy knowledge. Data sources from performance assessments, transfer teaching tasks, traditional pre- and post-assessments, and observations of classroom problem-solving sessions were used to make conclusions about the effectiveness of the model.

D2-6-5

Analysis and synthesis of studies related to the effectiveness of analogies in science learning

Zoubeida Dagher, University of Delaware

The purpose of this study is to critically examine studies dealing with the effectiveness of analogies in science learning in an effort to understand or explain apparent contradictions in findings. Theoretical treatments of analogies will be related to the analysis of empirical studies and a synthesis of our current state of knowledge of instructional analogies in science will be discussed. Based on this synthesis, areas in need of further investigation will be identified and a research agenda will be proposed. Also, a set of caveats and recommendations for teachers, teacher educators, and researchers will be presented.

STUDENTS' PROBLEM-SOLVING IN MECHANICS: PREFERENCE OF A PROCESS BASED MODEL

D2-6-6

Meir Meidav, Ruth Stavy, Zehava Asa, Tel Aviv University
Yoram Kirsch, The Open University, Israel

There are many problems in physics which can be solved by more than one theoretical model. For example, many problems in mechanics can be solved either by Newton's Laws of Motion or by the Law of Conservation of Energy. Research in science education has indicated the inexperienced solvers (novices) and experienced solvers (experts), use inappropriate models for solving problems. The objective of this study is to find out how physics-major high school students (novices) and high school physics teachers (experts) solve problems in mechanics and which model they use. Thirty-four eleventh grade students (novices) and twenty-two physics teachers took part in this study and received two types of problems: open-ended computational problems and multiple choice problems. The majority of the experts preferred a model based on the Law of Conservation of Energy (structure based model), while the novices preferred a model based on Newton's Laws of Motion (process bases model).

Discussion Group: Conceptualization/Proportion Reasoning
D2-7

AN ANALYSIS OF THINK-ALOUD PROTOCOLS OF STUDENTS' UNDERSTANDING OF THE MOLE CONCEPT AND ITS USE IN PROBLEM SOLVING

D2-7-1

John R. Staver and Andrew T. Lumpe, Kansas State University

The authors' purpose was to determine: 1) How students define the mole; 2) how students explain the numerical identity between the atomic/molecular mass of a substance and its molar mass; and 3) connections among students' definitions of the mole, their understanding of the numerical identity issue, and their ability to solve mole concept problems. Twelve college students enrolled in a chemistry course for students with little or no background in chemistry were the subjects. Each subject participated in a think-aloud protocol that focused on the authors' purposes. The authors content analyzed written transcripts of the audio taped think-aloud sessions. Results indicate that students vary in how they define the mole, and their definitions are connected to their understanding of the numerical identity issue. Moreover, students' understanding of the numerical identity issue is a major stumbling block in terms of their ability to solve two atomic mass calculations in the think-aloud protocol.

D2-7-2

A STUDY ON STUDENTS' CONCEPTIONS OF VAPORIZATION

Hwang, Bao-tyan
Department of Chemistry
Huang, Hsiang-wu
Department of Physics
National Taiwan Normal University

The concepts of vaporization are the important parts of teaching units in the science curriculum. It is widely accepted that a students's existing knowledge plays a critical role in his/her lerning science. In this study, a diagnostic group demonstration test concerning the conceptions of vaporization was conducted to the subjects in high school levels and college levels. In this way the students' misconceptions were classified by their thinking models according to the reasons they gave to justify their own answers. The relationship between the developmental characteristics of the spontaneous concepts of vaporization and the Piaget's operational stages of cognitive development was also investigated statistically. Some of the implications of the findings for teaching science were also discussed.

THE DEVELOPMENT OF CONCEPTIONS IN BASIC ELECTRICITY: AN APPLICATION OF 'TEACHING EXPERIMENT' METHODOLOGY. **D2-7-3**

Nggandi Katu, Vincent N. Lunetta, The Pennsylvania State University and Euwe van den Berg, Vrije Universiteit, Amsterdam

This study examined students' conceptions about basic electricity. It employed teaching experiment methodology (Steffe, 1983) to examine the process of the development of new concepts resulting from interactions with the teacher and hands-on activities with batteries, bulbs, wire, and resistors, and with teaching aids including circuit diagrams. The teacher/researcher interacted individually with each student in four to eight teaching episodes. The study indicated that students have their own conceptions about simple electric circuits resulting from earlier experiences with electricity in their daily lives and in school. They use different explanations of how and why circuits function. Some conceptions are held strongly and used consistently by the students. There are also conceptions that are not strongly held and that can be changed relatively easily. The study revealed that students sometimes change their conceptions as a result of interactions with the teacher and with hands-on activities, and they actively develop new concepts in the process. The study showed that some concepts were very difficult to teach with high fidelity to the conceptions of the physics community, and it suggests implications for teaching.

PROPORTIONAL REASONING AND FIELD DEPENDENCE: VARIATIONS ON THE CYLINDER PROBLEM. **D2-7-4**

Carol A. Lawton, Indiana - Purdue University at Fort Wayne

The effects of field dependence and structural variations in the Cylinder problem were examined with respect to the use of a proportional reasoning strategy. Subjects were presented with one of three versions of the Cylinder problem, in which the numerical content was held constant, but the salience of the difference between the two items in the problem was varied. Enhancing the perceptual difference between the two items by depicting them as being of different shapes and calibrated in different units of measurement did not change the likelihood of proportional reasoning, but the presence of discrete units for one of the items significantly improved performance. Significant effects of field dependence, sex, and math background were also found across the three problems. Applications to instruction in proportional reasoning are discussed.

D2-7-5

PROGRESSIVE "PROBLEMSHIFTS" BETWEEN DIFFERENT RESEARCH PROGRAMS IN SCIENCE EDUCATION: A LAKATOSIAN PERSPECTIVE.

Mansoor Niaz, Universidad de Oriente

Given the importance of epistemology and philosophy of science, Lakatos' methodology is particularly suited to evaluate competing research programs in science education. This paper has two objectives: 1) Evaluate critically the interpretations of Gilbert & Swift (1985) and Rowell & Dawson (1989); 2) Postulate a progressive "problemshift" between Piaget's epistemic subject and Pascual-Leone's metasubject. Regarding Gilbert & Swift it is concluded that the Alternative Conceptions Movement at its present stage of development cannot explain the previous success of its rival (Piagetian theory) nor supersede it by a further display of heuristic power. It appears that Rowell & Dawson approach would enrich Piagetian theory with more descriptive content rather than explanatory constructs. In contrast to Piaget's structural theory, Pascual-Leone considers his theory to be process-structural, as it explicitly represents the step-by-step temporal unfolding of subject performance. It is concluded that Pascual-Leone's theory extends Piaget's negative heuristic by introducing antecedent variables & also enriches the positive heuristic by introducing metasubjective task analyses.

General Session 3
D4

GIRLS IN SCIENCE: WHAT DO WE KNOW, WHAT DO WE NEED TO KNOW?

Susan McGee Bailey, Wellesley College Center for Research on Women, and Patricia B. Campbell, Campbell-Kibler Associates

Research on issues of gender and science has found that, unlike math, where gender differences in achievement and course taking are shrinking, gender differences in science are not decreasing and may be increasing. Yet, little attention has been given to girls in reform efforts within science education and education in general.

Drawing on a range of work from the National Assessment of Educational Progress to the impressions of individual 9th graders, Drs. Bailey and Campbell will discuss the "whys" and "wherefores" behind the science gender gap, including:

- teacher behavior that works and that doesn't work
- influences that encourage and discourage girls in science
- effects of girls' and boys' different in- and out-of-school science experiences
- the effects of increased research attention on issues of math and gender.

Building on their work on, **How Schools Shortchange Girls: A Study of Major Findings on Girls in Education**, Drs. Bailey and Campbell will conclude with a series of recommendations for research and for action.

Symposium: Self-Efficiency
D5-1

SELF EFFICACY RESEARCH IN SCIENCE EDUCATION.
Larry Enochs, National Science Foundation, Kansas State
Charlene M. Czerniak, The University of Toledo
Catherine G. Yeotis and Linda Bakken, Wichita State University
David Haury, The Ohio State University.

This symposium focuses on efficacy research in science education. Four papers address the following separate topics: methodological issues and problems in measuring personal and teacher efficacy, validity of an efficacy instrument as related to actual teacher behaviors, the effects of science leadership training on self-efficacy and teaching strategy selection of elementary teachers, and connections between self-perceptions in science and attitudes toward science teaching among elementary school teachers. Findings of the first paper show that personal efficacy scales have consistently had greater reliability scores than teacher efficacy scales and have correlated with variables theoretically related to higher efficacy. Findings of the second study support the notion that personal efficacy is related to teaching behaviors such as persistence, use of inquiry strategies, and questioning methods. The third paper shows that there is a significant relationship between higher level efficacy and inquiry teaching strategies. Conclusions from the fourth paper are inconclusive, but a link was found between control orientation and desire to interact with various resource people.

Contributed Papers: External Influence on Student Learning
D5-2

THE MEDIATING EFFECTS OF TEACHER-STUDENT RELATIONSHIP ON ACADEMIC RISK TAKING. D5-2-1

Mark Templin and Catherine Ebbs, University of Michigan.

The purpose of this study is to describe how the teacher-student relationship mediates the effect of background variables on academic risk taking behavior. This study used a random sample of 15% of schools from the NELS-88 data set. A causal path model was constructed of eight variables. Four exogenous variables: Standardized SES, Black, Hispanic, and Gender were included as student background variables. The four other variables were: Standardized Locus of Control, Educational Aspirations, Teacher-Student Relationship, and Academic Risk Taking. Teacher-Student Relationship and Academic Risk Taking were factors created from multiple NELS-88 variables. Results indicate that SES and Teacher-Student Relationship have large direct effects on Locus of Control and Educational Aspirations. Locus of Control, Educational Aspirations, Teacher-Student Relationship and Hispanic have significant direct effects on Academic Risk Taking. SES and Teacher-Student Relationship have relatively large indirect effects on Academic Risk Taking. The implications of these findings are discussed.

A DESCRIPTIVE STUDY OF URBAN MIDDLE SCHOOL STUDENTS' RELATIONSHIPS TO SCIENCE AND FAMILY. D5-2-2

John Wiggins, Mary M. Atwater, Catherine Gardner

Our society is becoming increasingly culturally diverse; the cultural diversity in the public schools reflects these changes. Scientific literacy is essential to survive in this technological world, but it appears that scientific literacy is not of high priority for many students. This research project was undertaken to gather demographic data, intentions to engage in science, reading and mathematics performance, and attitudes of urban, African-American middle school students. Scores on the Simpson-Troost Attitude Instrument, the Georgia Criterion Referenced Test, the Iowa Basic Skills Test were analyzed using Statistical Analysis System. Results indicated less than 50% of the students come from high school graduated parents who work full time to support the family. Less than 50% of these students indicated any interest to engage in science. A majority possess an uncertain attitude toward science, science teaching, and science curricula. However, sixth and eighth graders possessed high achievement motivation. All students possessed strong positive attitudes toward their families; eighth graders had a high self-concept.

D5-2-3

THIRD AND FOURTH GRADE PARENTS' IDEAS ABOUT AND INVOLVEMENT IN CHILDREN'S SCIENCE EDUCATION.
Elisabeth Charron, Montana State University.

The purpose of this study was to investigate parents' knowledge of, beliefs about, and involvement in their children's science education. Seventeen parents of third and fourth graders participated in in-depth interviews regarding these topics. Parallel data from the children of these parents was available from an earlier study. Some patterns in the parent interview data included: (1) scant to moderate knowledge of their child's school science activities; (2) better awareness of, and an encouraging level of involvement in, their child's home science activities; (3) a sense that school science activities should be active, directly linked to children's interests, and offered more often; and (4) general confidence in their child's science abilities, along with uncertainty about the degree to which their child would need extensive science training for the future. Implications for involving parents in modeling their own science interests more, and in supporting those of their children are discussed. Some response differences between mothers and fathers are also examined.

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Discussion Group: Predictors of Science Success/Choice
D5-3a

D5-3a-1

THE RELATIONSHIP AMONG STUDENTS' ATTITUDES TOWARD SCIENCE, MATH, ENGLISH, AND SOCIAL STUDIES

Wang Jianjun, Kansas State University
J. Steven Oliver, University of Georgia
Andrew T. Lumpe, Kansas State University

The researchers explored the relationship of student attitudes toward Science, Math, English, and Social Studies. The attitude information of high school students collected by the researchers conducting the Longitudinal Study of American Youth (LSAY) is treated as indicators of the students' attitudes in our data analysis. Besides some results about the pattern changes of the students' attitudes, our interpretation of the LISREL model suggests that the correlation between English and Social Studies is consistently higher than any other correlations, and the students' science attitude has strong and wide correlation with their attitudes in English, Math, and Social Studies.

D5-3a-2

THE RELATIONSHIP BETWEEN STUDENTS' FORMAL REASONING ABILITY, PRIOR KNOWLEDGE, APPROACHES TO STUDYING, AND THEIR PERFORMANCE IN CHEMISTRY

Frank J. Giuliano and Saouma B. BouJaoude, Syracuse University

The purpose of this study was 1) to investigate the relative influences of students' formal reasoning ability, prior knowledge, and their approaches to studying on their achievement in chemistry, and 2) to explore the relative influences of these same variables on student achievement with respect to problem type. Data on the 162 university students were collected using the Approaches to Studying Inventory, the Test of Logical Thinking, and content examinations. Results indicate that prior knowledge is the best predictor of achievement, while formal reasoning ability is the next best predictor. Prior knowledge is the only significant predictor of performance on problems with a relatively high mental demand, while prior knowledge, meaning orientation, formal reasoning ability and reproducing orientation are significant predictors of performance on problems with a relatively low mental demand.

MODIFIABLE PREDICTORS OF STUDENTS' ACADEMIC SUCCESS IN COLLEGE CHEMISTRY COURSES. **D5-3a-3**

Jeffrey R. Pribyl, Dept. of Chemistry; Elaine Hogen-Miller, School of Nursing; Marcia Stevens, School of Nursing; and D. Daryl Admams, Dept. of Biology, Mankato State University

Admission to college science and professional programs is dependent upon successful completion of beginning chemistry courses. University faculty from chemistry, biology, and nursing, melded knowledge from science education, nursing, and psychology literature to test modifiable variables which correlated with success in beginning college chemistry courses. A correlational design and Lazarus' stress model were used to test which variables: cognitive appraisal (motivation, cognitive ability and health behaviors), stress (threat, challenge, and stress of the course) and coping (self-efficacy and coping strategies) were predictive of students' success in beginning chemistry courses. Forward multiple regression revealed academic self-efficacy, cognitive ability, health risk behavior, and age to be predictive of course grade.

D5-3a-4

PATH ANALYSIS OF THE RELATIONSHIPS AMONG PARENTS' EDUCATION, LANGUAGE PREFERENCE, COGNITIVE DEVELOPMENT, ACADEMIC ABILITY, AND SCIENCE PROCESS SKILLS ACHIEVEMENT.

Paul J. Germann, University of Missouri-Columbia

This study's primary focus was to investigate the relationships among a) SES (parents' education), b) academic ability, c) cognitive development, and d) process skills achievement. Other variables of interest were gender, language preference, attitude, content preknowledge, and process skills preknowledge. Data was gathered from four ninth- and tenth-grade biology classes. Pearson correlation coefficients were calculated. Beta coefficients from regression analysis were used to test the path model. The effects of SES as well as attitude and gender seem to be mediated through cognitive development. Cognitive development appears to have its effect on science process skills mediated through academic ability. Academic ability, in turn, had major effects on biology preknowledge, science process skills preknowledge, and science process skills achievement.

AN ANALYSIS OF MYERS BRIGGS TYPE INDICATOR SCORES: FLORIDA WOMEN SCIENTISTS IN ACADEMIA

D5-3a-5

Carolyn Butcher Dickman, University of South Florida

The purpose of this study was to examine the personality types of women in academic science as tested by the Myers-Briggs Type Indicator (mbti). The criteria for inclusion in this study were possession of an advanced degree in a natural science and employment in a post secondary institution in Florida. The data were analyzed using: 1) a Pearson Product-Moment Correlation to determine the relationship between MBTI scores and age, 2) a One-Way Chi-square was used to test the frequency of types obtained from the MBTI, 3) ANOVAs were calculated and a Newman-Keuls Multiple Range Test was performwd on the significant means, and 4) a biserial correlation was calculated between continuous scores on the MBTI and marital status. Women scientists in the state of Florida were found to be increasingly introverted with increasing age. Married/widowed women's scores were significantly different on the Thinking-Feeling scale from those women who were single/divorced. These data need to be further explored for intensity. Whether all populations become more introverted with increasing age or if this is unique to women scientists in Florida is not known.

WOMEN SCIENTISTS IN ACADEMIA: FACTORS EFFECTING CAREER CHOICE

D5-3a-6

Carolyn Butcher Dickman, Meta Van Sickle, and John T. Bullock, University of South Florida

The purpose of this study was to identify factors which inhibited or encouraged women's interest in obtaining an advanced science degree and utilizing it in an academic setting. The combined effect of increased student enrollment and the underrepresentation of women will produce a significant shortfall of post secondary teachers, particularly in the natural sciences. Packets were sent to each potential subject containing: a letter from the researcher explaining the purpose and scope of the study, a Likert-type scale, and a stamped self-addressed envelope. Mothers were perceived as having a more positive attitude toward their married daughte working in a male dominated field than were fathers. However, both parents expected their daughters to wxcel in all school subjects and overall, displayed positive attitudes toward science and mathematics. Respondents displayed positive attitudes towards science courses throughout their formal schooling and perceived their peers' reactions toward their science/mathematical orientation as positive. Science teachers at various levels of their academic training strongly influenced their career choice.

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D5-3a-7

A STUDY OF THE RELATIONSHIPS BETWEEN C-BASE COMPOSITE AND SCIENCE SCORES, ACT SCORES, PRESERVICE ELEMENTARY STUDENTS PROCESS SKILLS.

John Settlage. Jr., TERC; Lloyd H. Barrow, Julie Cook, and Candace She; University of Missouri

The purpose of this study was to utilize the Second International Association for the Evaluation of Educational Achievement Science Study (SISS) test items to determine the relationship with C-BASE composite science scores and ACT scores of preservice elementary science methods students. Half of the grades five and nine tests were administered as a pretest and the remainder as the posttest. A total of 48 preservice students participated in the study. Data analysis revealed significant relationships between all variables except for the C-BASE composite and the posttest.

Discussion Group: Teacher Induction
D5-3b

D5-3b-1

DEVELOPMENT OF A SUPPORT MODEL TO AID BEGINNING MIDDLE SCHOOL SCIENCE TEACHERS

John R. Wiggins, Bethany Kim Nichols, Lewis Maxwell Monroe, and Michael J. Padilla, The University of Georgia

An NSF grant received in 1986 created a model middle grades science teacher education program which improved both the science content and the teaching methodology of preservice teachers. The present study offers case studies of three recent graduates with varying degrees of teaching experience. In addition to case study development, a follow-up induction plan was devised and implemented. The end result, based on the case studies and the induction plan, is a support model for beginning teachers having recently completed the middle grades science teacher education program. In developing the support model, areas of need were identified as perceived by both teachers and researchers. Researchers then provided assistance necessary to meet those needs. As a part of support model development, various components were field tested. The study was qualitative in nature and included interviews, observations, and document analysis. Slight modifications were made to the support model to accommodate the teachers' individual differences and their levels of experience.

D5-3b-2

DEVELOPMENT OF A SUPPORT MODEL TO AID BEGINNING MIDDLE SCHOOL SCIENCE TEACHERS.

John R. Wiggins Bethany Kim Nichols, Lewis Maxwell Monroe, and Michael J. Padilla, The University of Georgia

An NSF grant received in 1986 created a model middle grades science teacher education program which improved both the science content and the teaching methodology of preservice teachers. The present study offers case studies of three recent graduates with varying degrees of teaching experience. In addition to case study development, a follow-up induction plan was devised and implemented. The end result, based on the case studies and the induction plan, is a support model for beginning teachers having recently completed the middle grades science teacher education program. In developing the support model, areas of need were identified as perceived by both teachers and researchers. Researchers then provided assistance necessary to meet those needs. As a part of support model development, various components were field tested. The study was qualitative in nature and included interviews, observations, and document analysis. Slight modifications were made to the support model to accommodate the teachers' individual differences and their levels of experience.

D5-3b-3

DEVELOPMENT OF A SUPPORT MODEL TO AID BEGINNING MIDDLE SCHOOL SCIENCE TEACHERS

John R. Wiggins, Bethany Kim Nichols, Lewis Maxwell Monroe, and Michael J. Padilla, The University of Georgia

An NSF grant received in 1986 created a model middle grades science teacher education program which improved both the science content and the teaching methodology of preservice teachers. The present study offers case studies of three recent graduates with varying degrees of teaching experience. In addition to case study development, a follow-up induction plan was devised and implemented. The end result, based on the case studies and the induction plan, is a support model for beginning teachers having recently completed the middle grades science teacher education program. In developing the support model, areas of need were identified as perceived by both teachers and researchers. Researchers then provided assistance necessary to meet those needs. As a part of support model development, various components were field tested. The study was qualitative in nature and included interviews, observations, and document analysis. Slight modifications were made to the support model to accommodate the teachers' individual differences and their levels of experience.

Contributed Papers: Nature of Science/Curriculum Reform

D5-4

PROJECT 2061, PHASE II: THE CULTURE OF THE GEORGIA TEAM. **D5-4-1**

Mary Jo McGee-Brown, The University of Georgia

The purpose of this ethnographic study was to describe the culture of the Georgia Team during Phase II of Project 2061. Data were collected from all participants over a two year period using participant observation, conversational interviews, focus group interviews, diaries, and open-ended questionnaires. Data were collected during regular team work sessions, national Project 2061 team leaders meetings, team retreats, and national Project 2061 summer institutes. The goal was to understand the process of developing a rural model for 2061 from the perspectives of the Georgia team participants and facilitators. Data were analyzed using constant comparative analysis to generate categories from raw data. Support from collaborative interaction among teachers, consultants, university facilitators, and use of materials and computer equipment enhanced model development. National and local level problems were barriers throughout.

POLITICS, PROGRAMS, AND PEDAGOGY: PRIVATE SECTOR INFLUENCE ON SCIENCE EDUCATION POLICY REFORM IN MICHIGAN. **D5-4-2**

Stacey Marlow, The University of Michigan and Michael Marlow, Jackson County ISD

A variety of educational reform measures have been suggested, including collaboration between the private sector and public education. Since 1986, the State of Michigan has had collaborative program between business and public education, and has operationalized five regional mathematics and science centers for high school students. The purpose of this study is to examine the development and nature of that collaboration and its effect on science education, using two research lenses: first, an implementation model for policy analysis, and second, a constructivist learning model for curriculum and instruction analysis. Results are discussed in terms of the relationship of the private sector on policy, curriculum, and pedagogical practice, as well as the effects of policy on curriculum and pedagogical decisions made in the schools.

D5-4-3

AN INTERPRETIVE STUDY OF PROSPECTIVE TEACHERS' BELIEFS ABOUT THE NATURE OF SCIENCE.

Anthony Lorsbach, Bradley University

This study examined the beliefs about the nature of science constructed by pre-service teachers during their university studies. The study found that the participating teachers held objectivist-oriented beliefs: science was a search for truths, and theories were not a framework for research but were "almost truths." Epistemological and sociological interpretations of the experiences of pre-service teachers reveal inadaquacies of science teacher education and provide frameworks for discussion of experiences that may lead to pre-service teachers sharing beliefs about the nature of science with the science community.

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Discussion Group: Secondary School Science
D5-5a

D5-5a-1

HIGH SCHOOL STUDENTS' CONCEPTS REGARDING FOOD CHAINS AND FOOD WEBS: A MULTINATIONAL STUDY.

Charles R. Barman, Indiana University; Alan K. Griffiths, Memorial University of Newfoundland, and Peter A.O. Okebukola, Lagos State University

The purpose of this study was to examine the views of high school students with regard to food chains and food webs. This investigation included 128 randomly selected students from four countries; Australia, Canada, the United States, and Nigeria. Each subject was individually interviewed using the interviews about events method. During each interview, the investigator asked the subject a set of standard questions that was developed prior to the beginning of this study. Although the investigators identified some common misconceptions about food webs, it was generally concluded that students at this level tend to have a good understanding of this concept.

D5-5a-2

SURVEYING THE KNOWLEDGE OF BASIC BIOLOGY IN BRITISH AND AMERICAN TEENAGERS.

Thomas R. Lord, Indiana University of Pennsylvania

Recent surveys reveal that a large variation exists in knowledge of basic science within different regions of a country. Other studies on a more global scale have come to similar findings from one nation to another. Clearly, the level of scientific literacy in student and adult populations throughout the world is quite diverse. As a comparison, a study was conducted on basic life science knowledge in teenage populations in two English-speaking countries. Several hundred students in their mid-teen years in Great Britain were compared to the same aged students in the United States. Questions on the survey were intended for sixteen-year-olds in the twentieth through sixteenth percentile of intelligence. Students from both urban and rural schools were included in the sample. The survey concludes that overall there is no significant difference between the English and American population in basic life science knowledge. However, when the results were broken down by gender, it was found that males from the United States and females from Great Britain statistically outperformed their gender counterparts from the other country.

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D5-5a-3

THE DRAMA OF THE HAWKING-GOULD DICHOTOMY AND OTHER EVERYDAY SCIENTIFIC HAPPENINGS: APPLYING THE SCIENTIFIC THEORY PROFILE.

Cathleen Loving, California State University, Fresno

The writings of current scientists and the controversies they are involved in regarding rival theories provide good fodder for the development of a course on the nature of science for science teachers. The Scientific Theory Profile is used as a comparison between what the experts say about scientists' views concerning theories and what scientists themselves say. Research on these writings resulted in the development of a course mission, goals, objectives and sample concepts and activities. All of these contribute to an activity-centered course for science teachers that should help them develop their own perspective on the nature of science today.

D5-5a-4

MISSING THE MARK IN INTERPRETING AND PREDICTING OUTCOMES OF DIFFUSION AND OSMOSIS BY FIRST YEAR COLLEGE STUDENTS.

Rosie Allen-Noble, Montclair State College

The purpose of this study was to determine the nature of the subjects' internal representations of diffusion and osmosis, whether subjects could use the knowledge retrieved from memory in interpreting and predicting outcomes of diffusion and osmosis in new situations and whether knowledge restructuring occurred following completion of these tasks. Twenty-five novices and six experts responded to concept evaluation statements, think-aloud audio-recorded interviews and probe questions to five instances of diffusion and six instances of osmosis. First, novices and experts responses were compared to each other and then both groups were compared to "ideal responses" constructed from 15 college-level introductory biology textbooks. The results indicated that novices did not make accurate interpretations or predictions due in part to misunderstandings or misconceptions, inadequate knowledge bases, naive to transitional internal representations, inability to restructure knowledge and inability to establish connections between new concepts and currently held knowledge structures. Knowledge of what the students bring to the classroom will be beneficial in designing and teaching college-level introductory biology courses.

Discussion Group: Student Attitudes/Beleifs
D5-5b

D5-5b-1

STUDENTS' ATTITUDES TOWARD SCHOOL AND CLASSROOM SCIENCE: ARE THEY RELATED?

Patricia D. Morrell, Oregon State University

The purpose of this study was to determine if a relationship exists between student attitudes toward classroom science and school; and to determine the effect of grade level, ethnicity, gender, type of school/community environment, school/science self-reported achievement, and personal satisfaction with school/science achievement on these attitudes. Data were collected from fifth, seventh, and tenth graders using a Likert-type questionnaire and interviews. Results indicated that attitudes toward school and classroom science are significantly correlated. In addition, a trend of decreasing attitude toward classroom science and school from fifth to seventh and tenth grades was evident. The expected appearance of a more positive female attitude toward school in the lower grades and a less positive female attitude toward science in the upper grades was also seen.

D5-5b-2

TEACHING "NUCLEAR RADIATION" IN AN INTEGRATIVE APPROACH TO 10TH GRADE BIOLOGY STUDENTS: ACADEMIC ACHIEVEMENT AND ATTITUDES.

Michal Nachshon, Michal Shemesh and Reuven Lazarowitz,
Dept. of Education in Tech. & Science, Technion, Haifa, Israel.

The learning unit "Nuclear radiation, biological effects and uses" was taught to 10th grade biology students in an integrative approach, including knowledge in physics, chemistry, biology and societal issues. The sample consisted of 4 experimental classes (N=141) and a control group (3 classes; N=88). Both groups studied the atom structure and nuclear radiation in chemistry. The experimental group studied the learning unit and the control group studied immunology and microbiology. The study lasted two months, 2 weekly hours, in the classroom. Four teachers taught the 7 classes. The exp. group was assessed for academic achievement in chemistry and the learning unit and control group was assessed on chemistry. Both groups were assessed pre- and post-tests on attitudes toward nuclear radiation uses. Data were analysed by t-test and analysis of covariance. Results show that students' academic achievement on nuclear radiation was low after studying chemistry. On the learning unit, the experimental group achieved significantly higher scores on the post-test. On the pre-test attitudes, both groups scored a little above 3 on Likert scale of 5 points. On the post-test, students' attitudes in the experimental group were significantly higher while the control group attitudes did not change. Differences were found on attitudes by gender within and between groups. The importance of the integrative science teaching mode is supported by the study results.

D5-5b-3

THE EFFECTS OF LIVE- AND STUFFED-ANIMAL DISPLAYS ON THE ATTITUDES AND BEHAVIOR OF KINDERGARTEN STUDENTS.

Barry Brucklacher, Mansfield University

Science educators who have included live animals in their curricula have often reported that the animals were intrinsically interesting to students and enhanced the learning climate in the classroom. In this study, the researcher exposed four classes of kindergarten students to displays of live or stuffed guinea pigs for four weeks, and made videotaped recordings to measure how often students visited the displays and how long they stayed. Pretests and posttests were used to measure the children's attitude toward animal life and their attitude toward guinea pigs. Students exposed to the live animal made more visits and stayed at the display longer than students who were exposed to the stuffed animal, and these differences were significant at the .05 level. Gender, age, and pet ownership were not significantly related to the number or total length of visits in either treatment group, and there were not significant changes in attitude toward animal life or in attitude toward guinea pigs.

D5-5b-4

CASE STUDY OF A SIXTH GRADE CLASS: ATTITUDES AND CONCEPTIONS OF THE MARINE ENVIRONMENT

Thomas S. Howick, University of Southern Maine
Michael J. Padilla, University of Georgia

The purpose of this study was to investigate students' academic achievement and attitude towards the marine environment before, during, and after the Marine Science Project: FOR SEA experience. This case study was conducted with 19 students who experienced a 22 day unit regarding physical and biological aspects of the marine environment. Students' knowledge about the marine environment before and after their FOR SEA experience was measured by a pretest/posttest and "brain storming" (concept) maps. The students' attitudes toward the marine environment before and after their FOR SEA experience were measured by open-ended questionnaires, "brain storming" maps, interviews, and student journals. The students' attitudes towards the marine environment during FOR SEA were monitored by student journals, participant observation, and informal and formal interviews. There is significant positive gain in students' knowledge of the marine environment as a result of FOR SEA. Students' attitudes during the FOR SEA experience changed significantly toward the subject of pollution. Finally, the FOR SEA experience positively enhanced and/or changed students' prior attitude toward marine concepts.

D5-5b-5

Epistemological beliefs of students in high school physics

Hans Niedderer, Heinz Meyling, Thomas Bethge, Horst Schecker, University of Bremen, Germany

Two empirical investigations on students' matrices of understanding in mechanics and quantum physics had an additional focus on general frames of thinking related to science philosophy. A third study was directly focused on epistemological beliefs of students. All three studies were done with a qualitative approach using mainly an interpretive analysis of classroom protocols with additional data from questionnaires and interviews. Results give support to the general hypothesis, that there is a fundamental structural difference between everyday life thinking and science thinking which should be addressed in physics teaching. Other results show students' understanding of basic concepts in science philosophy, e.g. law, hypothesis and model, and their understanding of the scientific process envolving the interplay between theory and experiment.

Symposium: Student as Intuitive Investigator of the Natural World

D5-6

STUDENT AS INTUITIVE INVESTIGATOR OF THE NATURAL WORLD
Joesph Novak, Cornell University; Nancy Butler Songer, University of Colorado, Boulder; Marcia Linn, University of California, Berkeley; Robert Tinker & Andee Rubin, Technical Education Research Centers; Carl Berger, University of Michigan.

This symposium features four interventions which focus on students' investigations with natural world phenomena in science. These interventions follow a constructivists' perspective in their design and utilization of curricular activities which build on students' intuitive ideas, encourage integration of observations from many different contexts, recognize the social construction of science knowledge, and allow students to experience, design, and question scientific ideas in ways similar to that of scientists. While all presentations grapple with common questions about the complexities of integrating intuitive ideas with more formal science, individual presentations focus their discussions differently. Discussion highlights include: 1) real and idiosyncratic boundaries to knowledge development in elementary physical science, 2) the interaction of students' beliefs about the nature of science with knowledge development, 3) effective utilization of a "visual laboratory" which uses state-of-the-art technology and encourages appropriate questioning and reflection, and 4) the characterization of intuitive learning in efforts to impart intuition to more novice problem solvers. Results from these studies contribute to a greater understanding of the effective design and utilization of learning tools, activities, and strategies which provide meaningful science learning which bridges the natural world-formal knowledge gap, and which leads to rich qualitative understandings in science.

Round Table Responsive Interaction: Pedagogy of Complexity and Uncertainty of Scientific Thought
D5-7

Joan Russow and Erich Swartz, University of Victoria,B.C.
"Responsive Interaction: pedagogy of complexity and of uncertainty of scientific thought"

Usually in conferences concepts that are expressed in papers are those conceived at least six months prior to the conference. Rarely are papers substantially revised and presented in the light of concepts emerging during the interaction among the participants at a conference. Occasionally there are unexpected connections made at conferences which make aspects of some papers irrelevant, yet there is no forum for discussing these connections during the conference due to the predetermined formats of conferences On the last day of the conference, we would like to organize a session in which some of the conceptual connections that have emerged during the conference can be explored. In the paper that we will have prepared for the conference we discuss the need to encourage science teachers to move away from the devising, the condoning, and the fostering of models; models which have been devised to control and simplify complexity and to give the illusion of certainty.This paper will , however, be modified in the light of concepts emerging from the conference. In the session , we will use the modified paper not to conduct the session but only as a stimulus for interaction.

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HEDGEPETH	DAVID	C&I COLLEGE ED	BOX 870231 UNIV AL	TUSCALOOSA AL	35487-0231
HEJAILY	NICK	WILLIAMSVILLE SCHOOL		WILLIAMSVILLE NY	14260
HELLER	PATRICIA	1503 W. 26TH ST.		MINNEAPOLIS MN	55405
HELLY	MAGGIE	MOSLEY HIGH SCHOOL	501 MOSELY DR	LYNN HAVEN FL	32444
HERL	HOWARD	SCHOOL ED	UCLA	LOS ANGELES CA	90024
HEWSON	PETER W.	225 N. MILLS ST.		MADISON WI	53706
HIBBARD	MICHAEL K	POMPERAUG REGION SCHOOL DIST 15	286 WHITTEMORE RD PO BOX 395	MIDDLEBURY CT	06762
HOGAN-MILLER	ELAINE	DEPT. CHEM & GEO	BOX 40 MANKATO ST UNIV	MANKATO MN	56002-8400
HOLLIDAY	WILLIAM G	DEPT. C&I	UNIV MARYLAND	COLLEGE PARK MD	20742
HOOK	KARL	203 CAROTHERS HALL	FLORIDA ST UNIV	TALLAHASSEE FL	32306
HOOPER	CARL	NORMAN HALL	UNIV FLORIDA	GAINESVILLE FL	32611
HORTON	PHILLIP B.	SCI ED DEPT. FL INST OF TECHNOLOGY	150 W. UNIV BLVD.	MELBOURNE FL	32901
HOWICK	THOMAS	17 MORRILL AVE.		GORHAM ME	04038
HUANG	HSIANG-WU	CHEM DEPT. NAT. TAIWAN NORMAL UNIV	88, SEC. 5, ROOSEVELT ROAD	TAIPEI, TAIWAN 11718	R.O.C.
HUANG	WANCHU	4F #25 LN 65 LOHYEH ST.		TAIPEI, TIAWAN 10674	R.O.C.
HUFFMAN	DOUGLAS	409 KOEHLER RD		ST PAUL MN	55127
HUGHES	RONALD P.	SCHOOL ED CALIFORNIA ST UNIV	9001 STOCKDALE HWY	BAKERSFIELD CA	93311-1099
HUMPHREY	FAYE G.	DEPT C&I	UNIV NORTH CAROLINA	CHARLOTTE NC	28223
HUNT	ANITA	UNIV GA DEPT. SCI EDUC	212 ADERHOLD HALL	ATHENS GA	30602
HUPPERT	JEHUDA	SCHOOL ED-ORANIM	HAIFA UNIV	TIVON 36910	ISRAEL
HWANG	BAO-TYAN	CHEM DEPT. NAT. TAIWAN NORMAL UNIV	88, SEC. 5, ROOSEVELT ROAD	TAIPEI, TAIWAN 11718	R.O.C.
HYKLE	JACQUELINE A.	8654 BETHANY LN		CINCINNATI OH	45255
JACKSON	DAVID F.	212 ADERHOLD HALL	UNIV GEORGIA	ATHENS GA	30602

JACOBSON	LARRY	CT STATE DEPT. OF EDUCATION	PO BOX 2219	HARTFORD CT	06145
JAMES	ROBERT K.	EDUC C&I	TEXAS A&M UNIV.	COLLEGE STATION TX	77843-4232
JASALAVICH	SHEILA M.	800-11 IVY RIDGE RD.		SYRACUSE NY	13210
JEGEDE	OLU J.	DIST EDUC CENTER	UNIV S. QUEENSLAND	TOOWOOMBA 4350	AUSTRALIA
JENESS	MARK	W MICHIGAN UNIV DEPT ED	2423 SANGREN	KALAMAZOO MI	49008-3899
JONES	M. GAIL	1230 SUFFOLD CT		CARY NC	27511
KAHLE	JANE BUTLER	MIAMI UNIV	418 MCGUFFEY HALL	OXFORD OH	45056
KAMEN	MICHAEL	514 GREEN ST.		AUBURN AL	36830
KATU	NGGANDI	THE PENNYSLVANIA ST UNIV	241 CHAMBERS BLDG	UNIV PARK PA	16802-3206
KAZEN	DAVID	INGHAM ISD		MASON MI	48854
KELLY	GREGORY	DEPT. ED., 428 KENNEDY HALL	CORNELL UNIV	ITHACA NY	14853
KERBY	HOLLY WALTER	UNIV WISCONSIN - MADISON	500 LINCOLN DR	MADISON WI	53706
KERMIS	WILLIAM J.	P.O. BOX 501		WEATHERD OK	73096-0501
KERR	PATRICIA	CTR TCH & LRN, UNIV. N.D.	BOX 8158, UNIV STATION	GRAND KS ND	58202
KESIDOU	SOFIA	LRDC, ROOM 204 - UNIV PITTSBURG	3939 O'HARA ST.	PITTSBURGH PA	15260
KEYS	CAROLYN	2259 ELLINGTON		WALLED LAKE MI	48390
KILBURN	ROBERT E.	135 TOWER AVE.		NEEDHAM MA	02194
KIRSCH	YORAM	OPEN UNIV		TEL AVIV ISRAEL	69978
KOBALLA, JR.	THOMAS R.	SCI ED DEPT, 212 ADERHOLD HALL	UNIV GEORGIA	ATHENS GA	30602
KOKOSKI	TERESA M.	UNIV NEW MEXICO	CIMTE DEPT.	ALBUQQERQUE NM	87131
KRAJCIK	JOSEPH S.	SCH. ED, 610 E. UNIV	UNIV MICHIGAN	ANN ARBOR MI	48109-1259
KRESTAN	RONALD M.	KANSAS ST UNIV	219 BLUEMONT HALL	MANHATTAN KS	66502
KROCKOVER	GERALD H.	PURDUE UNIV	MATHEWS 115	WEST LAFAYETTE IN	47907
KUERBIS	PAUL J.	COLORADO COLLEGE	14 E. CACHE LA POUDRE	COLORADO SPRINGS CO	80903
KYLE, JR.	WILLIAM C.	444 JENNINGS ST.		WEST LAFAYETTE IN	47906-1146
LADEWSKI	BARBARA G.	UNIV MICHIGAN- SCHOOL EDUC	610 E. UNIV RM 1228	ANN ARBOR MI	48109-1259
LALIK	ROSARY V.	DIV. C&I	VA POLYTECHNIC INST & ST UNIV.	BLACKSBURG VA	24061-0313
LARKIN	JILL	CARNEGIE MELLON UNIV	5000 BES AVENUE	PITTSBURGH PA	15213
LARSON	JANE O.	PSC#78, BOX 4321		APO AP 96326-4321	JAPAN
LASHIER JR	WILLIAM S.	DEPT. C&I SCHOOL ED	207 BAILEY HALL UNIV KS	LAWRENCE KS	66045-2340
LATZ	MARK	DEPT. SCI ED - OREGON ST UNIV	WENIGER HALL 253	CORVALLIS OR	97331
LAVOIE	DERRICK	COLLEGE ED, 213 REID HALL	MONTANA ST. UNIV.	BOZEMAN MT	59717
LAWRENZ	FRANCES	OSED/EHR	NSF, 1800 G. ST. NW	WASHINGTON DC	20550
LAWSON	ANTON E.	DEPT. ZOOLOGY	ARIZONA ST UNIV	TEMPE AZ	85287-1501
LAWTON	CAROL A.	DEPT. PSYCH SCIS	INDIANA-PURDUE AT FT WAYNE	FORT WAYNE IN	46805
LAYMAN	JOHN W.	7500 SWEETBRIAR DR.		COLLEGE PARK MD	20740
LAZAROWITZ	REUVEN	DEPT. ED IN TECHNOLOGY & SCI	ISRAEL INST. TECH.	TECHNION HAIFA 32000	ISRAEL
LEACH	JEAN	W PARK PLACE ELEMENTARY	193 W PARK PLACE	NEWARK DE	19711
LEARY	ROSEMARY	3728 E. AHWATUKEE DR.		PHOENIX AZ	85044
LEDERMAN	NORMAN G.	WENIGER HALL 251	OREGON ST UNIV	CORVALLIS OR	97331-6508
LEE	TIEN-YING	#88, SEC. 5, ROOSEVELT RD.	NATIONAL TAIWAN NORMAL UNIV	TAIPEI, TAIWAN	R.O.C.
LEVY	JANE S.	UNIV MICHIGAN	1323 SEB-610 E UNIV	ANN ARBOR MI	48109
LIND	KAREN K.	1425 MCCARTIN DR.		NEW ALBANY IN	47150
LINN	MARCIA C.	4611 TOLLMAN HALL	GRAD SCH ED - UNIV CALIFORNIA	BERKELEY CA	94720
LOCKARD	J. DAVID	DEPT. C&I	UNIV MARYLAND	COLLEGE PARK MD	20742
LOMASK	MICHAEL J.	121 CLARENDON TERRACE		NEWINGTON CT	06111

LORD	THOMAS R.	BIOLOGY DEPT. WEYANDT HALL	INDIANA UNIV PENN.	INDIANA PA	15705
LORSBACH	ANTHONY W.	DEPT. TEACHER ED	BRADLEY UNIV	PEORIA IL	61625
LOUCKS-HORSLEY	SUSAN	THE NETWORK INC.	290 SOUTH MAIN ST	ANDOVER MA	01810
LOVING	CATHLEEN	5707 N PLEASANT		FRESNO CA	93711
LUCAS	KEITH B.	FAC ED QUEENSLAND UNIV TECH	LOCKED BAG #2	RED HILL, Q 4059	AUSTRALIA
LUCY	EDWARD C.	5760 REDCOAT RUN		STONE MOUNTAIN GA	30087
LUMPE	ANDREW	CENTER SCI ED	219 BLUEMONT HALL KSU	MANHATTAN KS	66506-5313
LUNETTA	VINCENT N.	241 CHAMBERS, COLL. EDUC.	PENNSYLVANIA ST UNIV	UNIV PARK PA	16802
MAGNUSSON	SHIRLEY	EDUC STUDIES, RM 1323 SEB	UNIV. MICHIGAN, 615 E. UNIV	ANN ARBOR MI	48109-1259
MAOR	DORIT	SMEC, CURTIN UNIV	GPO BOX U1987	PERTH 6001	AUSTRALIA
MAREK	EDMUND A.	SCI ED CENTER	UNIV OKLAHOMA	NORMAN OK	73019-0260
MARION	SCOTT F.	UNIV MAINE	COLL EDUC 307 SHIBLES HALL	ORONO ME	04469
MARLOW	MICHAEL	JACKSON COUNTY ISD	6700 BROWNS LAKE RD	JACKSON MI	49201
MARLOW	STACEY E.	UNIV MICHIGAN	1228 P SEB	ANN ARBOR MI	48109-1259
MARTENS	MARY LEE	2014 POTTER AVE.		N MERRICK NY	11566
MARTIN	DAVID J.	P.O. BOX 444 - DEPT. ECEE	KENNESAW ST COLLEGE	MARIETTA GA	30061
MARTIN	LAURIE	DEPT EDUC PSYCHOLOGY	UNIV SOUTH CAROLINA	COLUMBIA SC	29208
MASON	CHERYL L.	11840 CAMINTO RONALDO #131		SAN DIEGO CA	92128
MATTHEWS	MICHAEL R.	EDUC. DEPT.	UNIV AUCKLAND	AUCKLAND	NEW ZEALAND
MCCAHON	THOMAS	KANSAS ST UNIV	THOMPSON HALL	MANHATTAN KS	66506
MCCONNEY	ANDREW A.	FIT BOX 6012		MELBOURNE FL	32901
MCCURDY	DONALD W.	211 HENZLIK HALL	UNIV NEBRASKA-LINCOLN	LINCOLN NE	68585-0355
MCFADDEN	CHARLES P.	250 WOODBRIDGE ST.		FREDERICTON NB	E3B 4R3CANADA
MCGEE-BROWN	MARY JO	UNIV GEORGIA	EDUC PSYCH -ADERHOLD HALL	ATHENS GA	30602
MCGINNIS	J. RANDY	212 ADERHOLD HALL	DEPT SCI EDUC - UNIV GA	ATHENS GA	30602
MCGLAMERY	SHERYL L	203 CAROTHERS HALL	FLORIDA ST UNIV	TALLAHASSEE FL	32306
MCROBBIE	CAMPBELL	QUEENSLAND UNIV TECH	LOCKED BAG 2 CNTR MSE	RED HILL BRISBANE QLD	4059AUSTRALIA
MCWHIRTER	LISA	3616 OAKBRIAR		CHOCTOW OK	73020
MEADOWS	LEE	UNIV GEORGIA	212 ADERHOLD HALL	ATHENS GA	30602
MEICHTRY	YVONNE J.	1416 ILLINOIS AVE		STEVENS POINT WI	54481
MEIDAV	MEIR	SCHOOL ED	TEL AVIV UNIV	TEL AVIV 69978	ISRAEL
METCALF	TERI	TEXAS A&M UNIV	COLLEGE ED	COLLEGE STATION TX	77843-4232
MEYLING	HEINZ	UNIV BREMEN, INST. PHYSICS EDUC.	POSTFACH 330440	D2800 BREMEN	GERMANY
MINISTRELL	JIM	1900 SE 42ND	MERCER ISLAND HIGH SCHOOL	MERCER ISLAND WA	98040
MISITI, JR.	FRANK L.	3010 CIRCLE DRIVE	WOODS EDGE ESTS	BLLOMSBURG PA	17815-8913
MITCHENER	CAROLE P.	124 NORTH FRANKLIN AVE.		RIVER EST IL	60305
MOFFAT	NANCY	ARIZONA ST UNIV	COLLEGE ED	TEMPE AZ	85287-0911
MONROE	LEWIS M.	506 OVERBROOK DR		SENECA SC	29678
MONTEIRO	ROBERTO A.	UNIV JUIZ DE FORA-BRAZIL	JUIZ DE FORA #36 100	MINAS GERAIS	BRAZIL
MORRELL	PATRICIA D.	38464 HWY 99W		CORVALLIS OR	97330
MORRISON	DOUG	RUTGERS THE STATE UNIV OF NJ	NEWARK CAMPUS	NEWARK NJ	07102
MULVENON	SEAN	ARIZONA ST UNIV	DIV CURRIC AND INST	TEMPE AZ	85287-1011
MURPHY	NANCY	DEPT. EDUC.	UNIV ALASKA-FAIRBANKS	FAIRBANKS AK	99775-0600
NACHSHON	MICHAL	DEPT. EDUC IN TECH AND SCI	TECHNION-IIT	HAIFA ISRAEL	32000
NAIZER	GILBERT	4733 BROMPTON LANE		BRYAN TX	77802
NAKHLEH	MARY B.	DEPT. CHEM. 1393 BROWN BLDG	PURDUE UNIV	W LAFAYETTE IN	47907-1393

NIAZ	MANSOOR	UNIV DE ORIENTE	APARTADO POSTAL 90	CUMANA, ESTADO SUCRE 6101	AVENEZUELA
NICHOLS	SHARON E.	3147 ORTEGA DR		TALLAHASSEE FL	32312
NICHOLS	BETHANY KIM	380 MCDUFFIE DR.		ATHENS GA	30605
NIEDDERER	HANS	UNIV BREMEN, INST. PHYSICS EDUC.	POSTFACH 330440	D2800 BREMEN	GERMANY
NOLAND	KATHLEEN A.	UNIV ALABAMA	BOX 870231	TUSCALOOSA AL	35487-0231
NORMAN	KATHERINE I.	1719 ALABAMA		LAWRENCE KS	66044
NORMAN	OBED	535 PIERCE ST 336		ALBANY CA	94706
NORRIS	ROGER A.	UNIV IDAHO	ED 412	MOSCOW ID	83843
NOVAK	ANN M.	1312 COLGATE CIRCLE		ANN ARBOR MI	48103
NOVAK	JOSEPH D.	DEPT. ED KENNEDY HALL R421	CORNELL UNIV	ITHACA NY	14853-5901
O'BRIEN	GEORGE E.	11006 SW 137 PLACE		MIAMI FL	33186
OKEBUKOLA	PETER A.	DEPT. CURRICULUM STUDIES	LAGOS ST UNIV/PMR 1087	APAPA LAGOS	NIGERA
OLIVE	JOHN	UNIV GEORGIA	212 ADERHOLD HALL	ATHENS GA	30602
OLIVEIRA	M. TERESA	NEW UNIV LISBON	MONTE DA CAPARICA-ALMADA	2825 MONTE DA	PORTUGAL
OLIVER	J. STEVE	212 ADERHOLD HALL	UNIV GEORGIA	ATHENS GA	30602
ORPWOOD	GRAHAM	THE IMPACT GROUP	2180 YONGE STREET	TORONTO ONT M4S 2B9	CANADA
PADILLA	MICHAEL J.	212 ADERHOLD HALL	UNIV GEORGIA	ATHENS GA	30602
PANKIEWICZ	PHILIP R.	DEPT. BIOLOGY - SUNY, COLLEGE AT CORTLAND	P.O. BOX 2000	CORTLAND NY	13045
PANKRATIUS	WILLIAM J.	COLL. EDUC (ICS)	4505 MARYLAND RKWY - UNLV	LAS VEGAS NV	89154-3005
PARK	JOHN C.	MATH & SCI ED, CAMPUS BOX 7801	NORTH CAROLINA ST UNIV	RALEIGH NC	27695-7801
PARKER,	LESLEY H.	CURTIN UNIVERSITY OF TECHNOLOGY	GPO BOX U, 1987	PERTH,	W. AUSTRALIA 6001
PARSONS	SHARON	203D CAROUTHERS HALL, FSU		TALLAHASSEE FL	32301
PAULINE	RONALD	GANNON UNIV SCH EDUCATION	2551 WEST EIGHTH ST.	ERIE PA	16505
PEASLEY	KATHLEEN L.	MICHIGAN ST UNIV	252 ERICKSON HALL	EAST LANSING MI	48824
PEDERSEN	JON E.	314 GRADUATE ED	UNIV ARKANSAS	FAYETTEVILLE AR	72701
PEEBLES	PATSYE	LOUISIANA ST UNIV	DEPT CURRIC AND INSTR	BATON ROUGE LA	70803
PERRY	BRUCE E.	261 MCGUFFEY HALL	MIAMI UNIV	OXFORD OH	45056
PETERS	JOSEPH M.	COLL ED UNIV WEST FLORIDA	11000 UNIV. PKWY	PENSACOLA FL	32514
PIBURN	MICHAEL D.	ARIZONA STATE UNIVERSITY	COLLEGE OF EDUCATION	TEMPE, AZ	85287-0911
POLLARD	REBECCA J.	114 EHLINGER DR.		BRYAN TX	77801
POWELL	JANET CARLSON	830 N. TEJON ST. #405		COLORADO SPRINGS CO	80903
POWELL	RICHARD	UNIV NEVADA-LAS VEGAS	COLLEGE EDUC-ICS	LAS VEGAS NV	89154
POWERS	DONALD T.	818 GLENOAK ST.		MACOMB IL	61455
PRAIA	J. FELIX	PORTO UNIV		4000 PORTO	PORTUGAL
PRATHER	J PRESTON	1771 OLD BROOK ROAD		CHARLOTTESVILLE VA	22901
PRESTON	DENISE L.	820 JACKSON ST.		REYNOLDSVILLE PA	15851
PRIBYL	JEFFREY R.	DEPT CHEM. & GEOLOGY	BOX 40 MANKATO ST UNIV	MANKATO MN	56002-8400
PRIMAVERA	LOUIS	ST JOHNS UNIV	GRAND CEN & UTOPIA PKWYS	JAMAICA NY	11439
RADFORD	DAVID L.	P.O. BOX 3019 T.S.		RUSTON LA	71272
RAMEY-GASSERT	LINDA	113B SCOTT LOOP		FT SHERIDAN IL	60037
RAMSEY	JOHN	710 PARK KNOLL LANE		KATY TX	77450
REAP	MELANIE A.	1817 TEXAS ST		NORMAN OK	73071
REIF	FRED	CARNEGIE MELLON UNIV	5000 BES AVENUE	PITTSBURGH PA	15213
RENNIE	LEONIE J.	SCI & MATH ED CT CURTIN UNIV	GPO BOX U 1987	PERTH WA 6001	AUSTRALIA
RICE	DIANA C.	809 VALHALLA DR.		COLUMBIA SC	29223
RIDENOUR	NANCY	ITHACA HIGH SCHOOL	1401 N CAYUGA ST	ITHACA NY	14850
RIDGEWAY	DORI S.	208 E. MAYNARD AVE.		COLUMBUS OH	43202

RILEY	JOSEPH P.	212 ADERHOLD HALL	UNIV. GA	ATHENS GA	30602
RIVARD	LEONARD	COLLEGE UNIV DE SAINT-BONIFACE	200 CATHEDRALE AVE	WINNIPEG MANITOBA	R2H 0H7CANADA
ROBINSON	MICHAEL	UNIV NEVADA-RENO		RENO NV	89557-0095
ROBINSON	WILLIAM R.	DEPT. CHEM. 1393 BRWN BLDG	PURDUE UNIV.	W LAFAYETTE IN	47907-1393
ROGERS	LAURA N.	P.O. BOX 82		NORMAN OK	73070
ROGG	STEVEN R.	212 SHIBLES HALL, COLL ED	TRINITY COLLEGE, MERCY HALL	BURLINGTON VT	05401
ROMANCE	NANCY R.	7421 S.W. 15TH ST.		PLANTATION FL	33317
ROSS	CRYSTAL	CT STATE DEPT OF EDUCATION	P.O. BOX 2219	HARTFORD CT	06145
ROTH	WOLFF-MICHAEL	APPLEBY COLLEGE	540 LAKESHORE ROAD WEST	OAKVILLE ONT	L6K 3P1 CANADA
ROTH	MARIE	TIPPECANOE SCHOOL CORP		LAFAYETTE IN	47905
ROTH	KATHLEEN J.	116 ERICKSON HALL	MICHIGAN ST. UNIV.	EAST LANSING MI	48824
ROYCHOUDHURY	ANITA	MIAMI UNIV	1601 PECK BLVD	HAMILTON OH	45011
RUBBA	PETER A.	165 CHAMBERS BLDG.	PENN ST UNIV	UNIV PARK PA	16802
RUBIN	ANDEE	TERC	2067 MASSACHUSETTS AVE	CAMBRIDGE MA	02140-1338
RUSSOW	JOAN	UNIV VICTORIA-FAC EDUC	P.O. BOX 3010	VICTORIA BC CANADA	V8W 3N4
RYAN	JOSEPH M.	DEPT EDUC PSYCHOLOGY	UNIV SOUTH CAROLINA	COLUMBIA SC	29208
SAIGO	BARBARA W.	330 HIGHWAY 1065		INDEPENDENCE LA	70443-9497
SANCHEZ	JAIME H.	UNIV ANTOFAGASTA	EDUC COMPUTING CENTER	CASILLA 170	CHILE
SANDERS	LINDA R.	108 KISKIAC TURN		YORKTOWN VA	23693
SCANTLEBURY	KATE	UNIV. MAINE, COLLEGE ED	206 SHIBLES HALL	ORONO ME	04469
SCHARMANN	LAWRENCE C.	247 BLUEMONT HALL	KANSAS ST UNIV	MANHATTAN KS	66506
SCHECKER	HORST	UNIV BREMEN NW1	D 2800 BREMEN	D 2800 BREMEN	GERMANY
SCHMIDT	HANS-JURGEN	BUSCHEI 75		D-4600 DORTMUND 14	GERMANY
SCHMIDT	JULIE	UNIV DELAWARE	COLLEGE ED	NEWARK DE	19716
SCHRIVER	MARTHA	UNIV TOLEDO	2801 W BANCROFT ST	TOLEDO OH	43606
SCHWARTZ	ERICH	UNIV VICTORIA-FAC EDUC	P.O. BOX 3010	VICTORIA BC CANADA	V8W 3N4
SCHWARTZ	JOHN	ITHACA COLLEGE		ITHACA NY	14850
SCOATES	GWEN	UNIV GEORGIA	212 ADERHOLD HALL	ATHENS GA	30602
SENN	GARY	FLORIDA INSTITUTE TECHNOLOGY	SCI EDUC DEPT	MELBOURNE FL	32901
SETTLAGE	JOHN	TERC	2067 MASS AVE.	CAMBRIDGE MA	02140
SHE	CANDACE	DEPT . C&I 104 TOWNSEND HALL	UNIV MO-COLUMBIA	COLUMBIA MO	65211
SHEMESH	MICHAL	DEPT . EDUC IN TECH & SCI	TECHNION-IIT	HAIFA ISRAEL	32000
SHEPARDSON	DANIEL P.	DEPT. C&I, 414 ENAD	PURDUE UNIV.	WEST LAYFAYETTE IN	47907
SHERWOOD	ROBERT D.	PEABODY COLLEGE, BOX 330	VANDERBILT UNIV	NASHVILLE TN	37221
SHORE	LINDA S.	BOSTON UNIV-POLYMER CENTER	590 COMMONWEALTH AVE	BOSTON MA	02215
SHROYER	M. GAIL	229 BLUEMONT HALL	KANSAS ST UNIV	MANHATTAN KS	66506
SIDLIK	LAWRENCE	ARIZONA ST UNIV	DIV. CURRIC & INSTR	TEMPE AZ	85287-1011
SIMMONS	PATRICIA E.	212 ADERHOLD HALL	UNIV GEORGIA	ATHENS GA	30602
SIMPSON	DORTHY	MERCER ISLAND HIGH SCHOOL		MERCER ISLAND WA	98040
SIMPSON	PATRICIA R.	COLL SCI & TEC ST CLOUD ST UNIV	720 4TH AVE SOUTH	ST. CLOUD MN	56301-4498
SMITH	MIKE U.	857 ORANGE TERRACE		MACON GA	31201
SMITH	DARWIN	UNIV GEORGIA	212 ADERHOLD HALL	ATHENS GA	30602
SMITH	DEBORAH C.	112 WILLARD HALL COLLEGE ED	UNIV DELAWARE	NEWARD DE	19716
SONGER	NANCY BUTLER	SCHOOL EDUC, BOX 249	UNIV. COLORADO	BOULDER CO	80309-0249
SPECTOR	BARBARA S.	308 G DEPT SEC ED	UNIV SOUTH FLORIDA	TAMPA FL	33620-5650
SPIEGEL	GEORGE F.	UNIV TEXAS-AUSTIN	ED BLDG 340-SC ED CENTER	AUSTIN TX	78712

STAHL	ROBERT J.	SECONDARY ED	ARIZONA ST UNIV	TEMPE AZ	85287-1911
STANLEY	GENE	BOSTON UNIV		BOSTON MA	02215
STAVER	JOHN R.	CENTER SCI ED	219 BLUEMONT HALL KSU	MANHATTAN KS	66506-5313
STAVY	RUTH	SCHOOL ED	TEL AVIV UNIV	TEL AVIV 69978	ISRAEL
STEVENS	MARCIA	MANKATO ST UNIV	DEPT CHEMISTRY	MANKATO MN	56002
STIMPSON	VIRGINIA	MERCER ISLAND HIGH SCHOOL		MERCER ISLAND WA	98040
STOCKER	ANN	FLORIDA INST. TECH.	DEPT. SCI ED	MELBOURNE, FL	32901
STOFLETT	RENE T.	NORTHERN ILLINOIS UNIV	DEPT C&I	DEKALB IL	60115
STUESSY	CAROL L.	DEPT. EDCI	TEXAS A&M UNIV	COLLEGE STATION TX	77843
SULLENGER	KAREN S.	CURR & INST FAC ED	UNIV NEW BRUNSWICK, BAG #45333	FREDERICTON N. R.	CANADA
SUNAL	CYNTHIA S.	C&I COLLEGE ED	BOX 870231 UNIV AL	TUSCALOOSA AL	35487-0231
SUNAL	DENNIS W.	C&I COLLEGE ED	BOX 870231 UNIV AL	TUSCALOOSA AL	35487-0231
SUNDBERG	MARSHALL D.	LOUISIANA ST UNIV	DEPT C & I	BATON ROUGE LA	70803
SVOLOPOULOS	VASILIOS	417 E. 90TH APT 7G		NEW YORK NY	10128
SWIFT	J. NATHAN	ED POUCHER HALL	SUNY-OSWEGO	OSWEGO NY	13126
SYANG	ANCHIR ANGEL	415 W 39TH ST. #107		AUSTIN TX	78751
TAMIR	PINCHAS	GRADUATE SCHOOL ED	UNIV CA SANTA BARBARA	SANTA BARBARA CA	93106
TEMPLIN	BRIAN	HOLT HIGH SCHOOL	1784 N AURELIUS RD	HOLT MI	48842
TEMPLIN	MARK	3121 ALGONQUIN		TOLEDO OH	43606
THORLEY	N. RICHARD	GRAD SCHOOL ED/HUMAN DEVLP.	UNIV ROCHESTER	ROCHESTER NY	14627
TINKER	ROBERT	HOLT HIGH SCHOOL	1784 N AURELIUS RD	HOLT MI	48842
TIPPINS	DEBORAH	212 ADERHOLD HALL	SCI ED DEPT, UNIV GEORGIA	ATHENS GA	30602
TIROSH	DINA	TEL AVIV UNIV	SCHOOL EDUC	TEL AVIV 69978	ISRAEL
TOBIN	KENNETH G.	203 CAROTHERS HALL	FLORIDA ST UNIV	TALLAHASSEE FL	32306
TOMANEK	DEBRA	SU STATION BOX 5517	NORTH DAKOTA ST UNIV	FARGO ND	58105
TOTHERO	MELISSA L.	UNIV TEXAS-AUSTIN	SC EDUC CENTER	AUSTIN TX	78712
TRAMMEL	RICK	ARIZONA ST UNIV	COLLEGE ED	TEMPE AZ	85287-0911
TRUMBULL	DEBORAH J.	426 KENNEDY HALL DEPT ED	CORNELL UNIV	ITHACA NY	14853-4203
TULIP	DAVID F.	QUEENSLAND UNIV TECHNOLOGY	LOCKED BAG NO 2	RED HILL	AUSTRALIA 4059
TULL	DELENA	105 LEWIS SCI CENTER	UNIV CENT ARKANSAS	CONWAY AR	72035
TWIEST	MARK G.	INDIANA UNIV PA	313 DAVIS HALL-IUP	INDIANA PA	15705
TWIEST	MEGHAN	313 DAVIS HALL	INDIANA UNIV PENN.	INDIANA PA	15705
TWIEST	GILBERT	CLARION UNIV		CLARION PA	16214
VAN DEN BERG	ED	CTR DEVLP COOPN SVCS	VRIJE UNIVERSITEIT	1081 BT AMSTERDAM	NETHERLANDS
VAN SICKLE	META	4202 EAST FOWLER AVE	UNIV SOUTH FLORIDA	TAMPA FL	33620
VAN ZEE	EMILY H.	DEPT. PSYCHOLOGY, N125	UNIV WASINGTON	SEATTLE WA	98195
VERDI	MICHAEL P.	13040 E. SHANGRI-LA		SCOTTSDALE AZ	85259
VESILIND	ELIZABETH	UNIV NC-CHAPEL HILL	CB #3500-UNC CH	CHAPEL HILL NC	27599-3500
VITALE	MICHAEL R.	SCHOOL ED	EAST CAROLINA UNIV	GREENVILLE NC	27858
VOSS	BURTON E.	1323B SCHOOL ED	UNIV MICHIGAN	ANN ARBOR MI	48109
WANDERSEE	JAMES H.	223-F PEABODY HALL	LOUISIANA ST UNIV	BATON ROUGE LA	70803
WANG	JIANJUN	KANSAS ST UNIVERSITY	219 BLUEMONT HALL	MANHATTAN KS	66502
WARDEN	MELISSA A.	DEPT. BIOLOGY	BALL ST UNIV	MUNCIE IN	47306
WARREN	CHARLES R.	ERIC/SMEAC	1200 CHAMBERS RD, ROOM 310	COLUMBUS OH	43212
WATSON	SCOTT B.	DEPT SCI D	EAST CAROLINA UNIV	GREENVILLE NC	27858-4353
WAX	NAOMI	SCHOOL ED	TEL AVIV UNIV	TEL AVIV 69978	ISRAEL

WEBER	SUZANNE	BOX 451, R#3 WEST LAKE RD.	OSWEGO NY	13126	
WEST	RONALD	KANSAS ST UNIV	219 BLUEMONT HALL	MANHATTAN KS	66506
WESTBROOK	SUSAN L.	508 CHAUTAUGUA		NORMAN OK	73069
WESTERBACK	MARY	LONG ISLAND UNIV	DEPT. GEOLOGY	BROOKVILLE NY	11548
WIER	ELIZABETH A.	UNIV DELAWARE	COLLEGE EDUC	NEWARK DE	19716
WIGGINS	JOHN R.	315 ADERHOLD HALL	UNIV GEORGIA	ATHENS GA	30602
WILLIAMS	RICHARD L.	FACULTY EDUC. P.O. BOX 3010	UNIV VICTORIA	VICTORIA BC V8W 3N4	CANADA
WILLIAMSON	VICKIE M.	222 CREST PLACE		NORMAN OK	73071
WINTER	CHRISTA R.	TEACHER ED PROGRAMS	LEWIS & CLARK COLLEGE	PORTLAND OR	97219
WOODS	AMANDA L.	1470 SHEAFE AVE 109		PALM BAY FL	32905
WRIGHT	EMMETT L.	237 BLUEMONT HALL	KANSAS ST UNIV	MANHATTAN KS	66506-5310
YEANY	RUSSELL H.	315 ADERHOLD HALL	UNIV GEORGIA	ATHENS GA	30602
YEOTIS	CATHERINE G.	WICHITA ST UNIV	BOX 28	WICHITA KS	67208
YORE	LARRY D.	2052 HARDY TERRACE		SAANICHTON BC V0S 1M0	CANADA
YOUNG	DEIDRA J.	RSRCH FELLOW SCI & MATH EDUC CTR	CURTIN UNIV TECH.GPO BOX U1987	PERTH WA 6001	AUSTRALIA
ZIELINSKI	EDWARD J.	CENTER SCI ED	CLARION UNIV	CLARION PA	16214
ZOHAR	ANAT	SCHOOL ED - ISRAEL SCI TEACHING	CENTER HEBREW UNIV	JERUSALEM 91	ISRAEL
ZOLLER	URI	DIV CHEMICAL STUDIES DEPT. SCI ED	HAIFA UNIV - ORANIM	PO KIRYAT TIVON 36910	ISRAEL
ZUCKERMAN	JUNE T.	67 NORTH MANHEIM		NEW PALTZ NY	12561